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Impact of Ebola outbreak on reproductive health services: implementing an ambulance referral system in a rural district of Sierra Leone

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ABSTRACT

Objectives To assess the utilisation of maternal and child health (MCH) services before, during, and after the Ebola virus disease outbreak.

Design A prospective observational study of MCH services.

Setting Pujehun district in Sierra Leone. Data was collected from 77 community health facilities and 1 hospital over a 6-year period from January 2012 to December 2017.

Main outcome measures The utilisation of MCH services was evaluated by assessing: i) institutional deliveries, Cesarean-sections, paediatric and maternity admissions, paediatric and maternity deaths, and major direct obstetric complications, at hospital level; ii) ante natal care 1 and 4, institutional delivery, and family planning, at community level. The contribution of a strengthened referral system was also analysed.

Results At hospital level, data between the Ebola period and the pre-Ebola period shows a statistically significant increase in the number institutional deliveries (p=0.02) and a reduction of maternal deaths (p=0.042). There was statistical significance between the post Ebola vs Ebola period, and post Ebola vs pre-Ebola periods for all indicators considered. At community level, with the exception of family planning, the differences between the Ebola period and pre-Ebola period are statistically significant for all indicators: institutional delivery ($p < 0.001$), ANC 1 ($p = 0.042$), and ANC 4 ($p = 0.008$). The differences between averages of the post Ebola vs pre-Ebola were significant, with an increase for institutional delivery ($p < 0.001$) and ANC 4 ($p < 0.001$). However, there was a statistically significant negative difference between trends in the two periods, for all the variables considered. The RS determined a significant increase in major direct obstetric complications and pediatric cases.

Conclusions Due to the strengthened referral service and a stronger health system compared to other districts in Sierra Leone, health facilities in Pujehun district, at community and hospital level, were able to maintain service provision and uptake during and after the Ebola epidemic.

Keywords: Ebola, Sierra Leone, Maternal and Child Health indicators, Referral system, Reproductive health service.

Strengths and limitations of this study

- The study uses data from a remote rural district in Sierra Leone, with a 6-year observational period. Data have been collected in a prospective way, reducing the potential bias in the accuracy of the data reported by other studies carried out in countries affected by Ebola.
- The pre, intra, and post-Ebola periods data, allowed a comparison between trends.
- The data refers to a single area of Sierra Leone: the sample cannot be considered representative of the country as a whole.

INTRODUCTION

The 2014-2015 Ebola Virus Disease (EVD) outbreak was the most severe in history, mainly affecting three West African countries; Guinea, Sierra Leone and Liberia. Overall 28,616 people were infected of which 11,310 died and the outbreak was declared a global public health emergency by the WHO.[1] Of the three countries affected, Sierra Leone had the most confirmed cases (8,704), which accounted for 50% of all confirmed cases in West Africa, and 3,589 deaths.[2-4] All 14 districts in Sierra Leone were affected, but at different times and to varying degrees.[5] During the Ebola crisis the population's trust in the national health system declined in Sierra Leone, leading to an overall reduction in the use of health services, including reproductive, maternal, and child services.[6-8] Underlying factors for the decrease in the use of health services included fear of infection, for both healthcare workers and patients, the underlying fragility of the health systems, the reduced numbers of available health personnel, and the death of healthcare workers due to EVD.[9 10] It has been estimated that 30% of health workers who died of EVD in West Africa were maternal and child healthcare (MCH) providers.[11] However, there were considerable variations in the reduction of health service uptake when looked at by district level in Sierra Leone.[6 12-14] While districts such as Kambia, Port Loko and Bonthe showed large reductions in facility-based delivery (between 38-41%), the district of Pujehun showed only a 5% decrease in the same service. Similar geographic variations were seen in the reduction in antenatal care (ANC) visits.[12 13]

The number of confirmed EVD cases - and deaths - varied considerably by district. There were no more than 100 confirmed cases in both Bonthe and Pujehun, and up to 4,000 confirmed cases in both Port Loko and Bombali.[15] However, public fear of Ebola, regardless of the actual number of cases per district, may still have prevented many people from accessing services. The challenge of providing adequate levels of care during a humanitarian emergency such as the EVD crisis was further exacerbated by the weak health system in Sierra Leone, particularly in rural areas where the poor condition of the roads and high transport costs cause delays in accessing services, and contribute to increased maternal and neonatal mortality.[16] Different types of referral systems (RSs) such as motorbikes were present in the country in the pre Ebola period to transport patients from the villages to the nearest health facility. Ambulances were also present in several districts with 73% of health facilities nationwide having a functioning RS, 59% of them consisting of an ambulance on call.[12 17] In the Pujehun district, the RS was barely functioning, only able to support the activity of a limited number of Peripheral Health Units (PHUs). The service was also entirely

funded by the patients themselves, resulting in underutilization of the service. Utilization was further reduced during the outbreak, when the ambulances were identified by the population with the transport of Ebola infected patients, and their use occasioned fear and distrust.

Doctors with Africa (DwA) CUAMM is an Italian NGO working in Sierra Leone since 2012. It is present in the Pujehun district focusing on MCH care both at hospital and community level.[18] In January 2015, in collaboration with the Ministry of Health and Sanitation (MoHS) of Sierra Leone and UNICEF, DwA began the re-organisation and reinforcement of the RS, transferring pregnant women and pediatric cases from PHUs to the Pujehun hospital. Our previous study carried out in the district of Pujehun showed that activities undertaken to manage the EVD outbreak and preserve MCH services at the district hospital and at the community level reduced the spread of infection and the impact of the disease on MCH services.[18] As widely reported in our previous study, the approach implemented in the Pujehun district avoided vertical interventions: it worked on strengthening all the components of the health system - governance, human resources, community involvement - before, during, and after the epidemic. The previous study[18] provided information only on three MCH indicators, namely pediatric admissions, maternity admissions, and institutional deliveries; in addition it did not assess the trends in the post-EVD period. Existing studies examining the influence of EVD on MCH services targeted the outbreak and the immediate post-outbreak periods.[19-22] Understanding the trends in the use of MCH services before, during, and after the EVD outbreak will help to guide post-EVD interventions, increasing access to MCH services in rural Sierra Leone. This information will also be useful in preparing a more organised and structured RS. With this background, the aims of this study are: i) to assess institutional deliveries, C-sections, paediatric and maternity admissions, paediatric and maternity deaths, and major direct obstetric complications (MDOCs), before, during, and after the EVD in the Pujehun hospital, thus complementing the results of the previous report which were limited to 3 MCH indicators; ii) to assess the use of ANC 1 and 4, institutional delivery, and family planning, at community level. This study was carried out in conjunction with the strengthening of an RS initiated a few weeks after the Pujehun district was declared Ebola-free.

METHODS

Setting

Sierra Leone has four provinces that are divided into 14 districts. Pujehun is one of four districts in the southern province. It has a population of approximately 375,000 inhabitants. The primary care network included 77 MoHS PHUs, 5 of which provide basic emergency obstetrics care (BEmOC). The secondary care system consists of the MoHS provided district hospital, which comprises the MCH complex, providing comprehensive emergency obstetric and newborn care (CEmONc) services. Connections between the community and health facilities are difficult because of the very poor condition of the roads. Furthermore, the district is divided by a major river (Moa River) and has a riverine area reachable only with boats, which further hinders access. The first case of Ebola in Pujehun district was reported on the 7th July 2014. The district was declared Ebola free on the 10th January 2015.[23] A total of 49 patients were registered with a case fatality rate of 85.7% (42/49).

Referral system

In the Pujehun district, two ambulances managed by the District Health Management Team (DHMT) were functioning in the pre Ebola period, but only 63% of the PHUs were able to use the service.[12 17] Emergency calls were not coordinated by the hospital and the transport costs were covered by the patients, dissuading many from using the service. During the outbreak, people came to associate the ambulances with transporting Ebola infected patients, which further discouraged their use. A 24-h free-of-charge ambulance RS, transferring pregnant women with obstetric complications from the health centers to Pujehun hospital was implemented in January 2015. In the hospital a call center was established and the call center number was distributed to all the 77 PHUs. Private calls were considered only in the case of an emergency or if the staff of the PHU were not available. After confirming an emergency condition together with the PHU staff, the hospital midwife had the responsibility to authorize the referral. A nurse on duty from the maternity hospital accompanied the driver in each referral. PHU staff were trained together with the hospital staff and DHMT to recognize and manage obstetric emergencies. All healthcare workers involved in the emergency transfer system received regular feedback on the appropriateness of each referral carried out. Referrals were carried out by 3 ambulances, two positioned in the Pujehun MCH complex, and a third one in Jendema, bordering Liberia, on the

opposite side of the Moa River. Around the Jendema area, 15 PHUs were located serving a population of approximately 80,000 inhabitants. Referrals in this area were made using the ambulances and by transferring patients at the river crossing point via a barge or a motor boat, depending on the flow rate of the river. Pediatric referrals were performed using private motor bikes available in the villages and hired from PHUs staff without the involvement of the call center. A referral form describing the clinical case and the justification for the referral was distributed to all the PHUs. The bike rider, after bringing the patient to the pediatric ward, delivered the referral form and received the reimbursement. For all patients carried to the hospital information was collected, including demographics, location, and the reason for contacting the RS. Community awareness activities were organized about the RS through meetings and radio discussions held by the DMHT, hospital health personnel, and local authorities.

Study design, population, and period

A prospective observational study using routinely collected health services data, from January 2012 to December 2017, was carried out. Three time periods were considered: pre- Ebola period (1st January 2012 – 30th May 2014); Ebola period (1st June 2014 – 28th February 2015); post- Ebola period (1st March 2015 – 31th December 2017). We considered the Ebola period from one month before the first confirmed case in the district (i.e. June 2014), to three months after the last confirmed case in the district (i.e. February 2015). This was done because in Sierra Leone the outbreak had started in other districts of the country before the first case registered in Pujehun and continued to affect other districts until November 2015. It is realistic to assume that public fear of potential EVD cases and lack of confidence in the health services persisted in the Pujehun population during that time.[14] In addition, expanding the Ebola period enabled a full assessment of the impact of the disease with an adequate comparison with the two long periods before and after the Ebola epidemic.

Data collection

Data on MCH indicators was prospectively collected from hospital registers (maternity ward, delivery unit, pediatric ward, operating theatre) directly by DwA. The following variables were collected: 1) paediatrics admissions per month; 2) pediatric deaths per month; 3) maternity admissions per month; 4) maternal deaths per month; 5) deliveries per month; 6) C-sections per

month; 7) MDOC cases per month. At community level, the following variables were collected from the local district Health Management Information System, with the technical support of DwA: 1) family planning consultations per month; 2) deliveries per month; 3) ANC 1 per month; 4) ANC 4 per month. Different variables were collected from the two types of sites, based on the different services provided at community level (BEmONC) and at hospital level (CEmONC). For the RS, data was collected from records of all of the study sites, including delivery registers, delivery logbooks, prenatal registers, referral registers, and death registers. Additional data was collected from the ambulance database and logbook. Records in the database were then validated by cross-checking the records with registers at the study sites.

Statistical analysis

For each indicator, a segmented seasonal autoregressive model of order 1 was estimated. The segments defined the three periods: before the EVD epidemic (January 2012 to May 2014), during the epidemic (June 2014 to February 2015), and after the epidemic (March 2015 to December 2017). The model for each indicator Y_t collected at hospital or community level was as follows: $Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \beta_4 Z_t + \beta_5 Z_t T_t + \beta_6 Month + \varepsilon_t$. β_0 estimates the number of individuals using the service at the beginning of the pre-Ebola period; β_1 estimates the average monthly change in the number using the service over the pre-outbreak period; T_t is the time since the start of the study; β_2 represents the change in the level of service use that occurred in the period immediately after the EVD period (designated by indicator variable X_t); β_3 represents the difference between the trend in service use during the EVD outbreak compared to the pre-disease period; β_4 represents the change in service use that occurred in the period immediately after the end of the outbreak (post-outbreak period designated by indicator variable Z_t); β_5 is the difference between the trend in service use during the period after the Ebola virus disease outbreak compared with the period during the outbreak period; β_m represents a series of indicator variables for each calendar month, and t is the random error term. Overall trends across the periods and the comparisons among trends were calculated as follows: linear trend during the outbreak = $\beta_1 + \beta_3$; linear trend after the outbreak = $\beta_1 + \beta_3 + \beta_5$; and linear trend after the outbreak vs linear trend before the outbreak = $\beta_3 + \beta_5$. Average levels across the periods and their comparisons were calculated as follows: average during the outbreak = $\beta_0 + \beta_2$; average after the outbreak = $\beta_0 + \beta_2 + \beta_4$; and difference between after the outbreak and before the

outbreak = $\beta_2 + \beta_4$. Differences were considered statistically significant at $p < 0.05$. The analysis was performed using R.[24]

Patient involvement

No patients were involved in defining the research question or the outcome measures, nor were they involved in the design and implementation of the study. There are no plans to involve patients in the dissemination of the results.

RESULTS

Hospital level: Pre-Ebola period

At hospital level, the pre Ebola period for MCH indicators showed an average of 49 maternal admissions per month (95% CI 37 to 61, p <0.001), 9 C-sections per month (95% CI 4 to 14, p=0.001), and 16 MDOCs per month (95% CI 5 to 26, p=0.003). There were an average of 46 pediatric admissions per month (95% CI 10 to 82, p=0.011), and 27 institutional deliveries per month (95% CI 19 to 34, p <0.001). For all indicators, the trend is stable during the pre Ebola period, without significant changes (Table 1 and 2; Figure 1 and 2).

Hospital level: Ebola vs pre-Ebola period

At hospital level, the differences between Ebola period vs pre-Ebola averages show a statistically significant increase for institutional deliveries (11, 95% CI 2 to 21, p = 0.02) and for the reduction of maternal deaths (-1, 95% CI - 2 to 0, p = 0.042). There is also a statistically significant difference between the trend of Ebola period vs pre-Ebola period, for maternal admissions (7, 95% CI 4 to 11, p <0.001), MDOCs (4, 95% CI 1 to 7, p = 0.006), and institutional deliveries (4, 95% CI 2 to 6, p = 0.001) (Table 1 and 2; Figure 1 and 2).

Hospital level: Ebola vs post-Ebola period

At hospital level, the differences between averages of the post Ebola vs Ebola are statistically significant for all indicators: institutional deliveries, C-sections, paediatric and maternity admissions, paediatric and maternity deaths, and MDOCs. There is also a negative trend in the transition from Ebola to post Ebola for maternal admissions (-7, 95% CI -10 to -4, p <0.001),

MDOCs (-4, 95% CI -7 to -1, p 0.009) and institutional deliveries (-3, 95% CI -5 to -1, p 0.001) (Table 1 and 2; Figure 1 and 2).

Hospital level: Post-Ebola vs pre-Ebola period

The differences between averages of the post Ebola vs pre-Ebola periods are also statistically significant for all indicators, except for maternal deaths. The differences between trends between post-Ebola vs pre-Ebola period are only significant for pediatric admissions (3, 95% CI 0 to 5, p 0.035) (Table 1 and 2; Figure 1 and 2).

Table 1 Maternal admissions, maternal deaths, C-sections, and MDOCs at hospital level

	Maternal admissions			Maternal deaths			C-sections			MDOC		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	7	-7 to 22	0.333	-1	-2 to 0	0.042	5	-1 to 11	0.13	2	-11 to 14	0.782
Difference between average of post-Ebola period vs Ebola period	43	28 to 58	<0.001	2	1 to 3	0.001	15	8 to 21	<0.001	41	30 to 54	<0.001
Difference between average of post-Ebola period vs pre-Ebola period	50	37 to 64	<0.001	1	0 to 2	0.135	19	13 to 25	<0.001	43	31 to 54	<0.001
Pre-Ebola period												
Number of events over pre-Ebola period (β_0)	49	37 to 61	<0.001	1	0 to 2	0.026	9	4 to 14	0.001	16	5 to 26	0.003
Trend in number over pre-Ebola period (β_1)	0	0 to 1	0.281	0	0 to 0	0.677	0	-0 to 0	0.999	0	0 to 0.5	0.768
Ebola period												
Average monthly change in number over Ebola period (β_2)	-40	-60 to -19	<0.001	0	-2 to 0	0.480	2	-7 to 11	0.668	-11	-29 to 6	0.207
Difference between trend of Ebola period vs pre-Ebola period (β_3)	7	4 to 11	<0.001	0	0 to 0	0.605	1	-1 to 2	0.346	4	1 to 7	0.006
Post-Ebola period												
Average monthly change in number during post-Ebola period (β_4)	11	-7 to 30	0.23	1	0 to 2	0.258	13	5 to 21	0.001	16	0 to 32	0.044
Difference between trend of post-Ebola period vs Ebola period (β_5)	-7	-10 to -4	<0.001	0	0 to 0	0.665	-1	-2 to 0.8	0.433	-4	-7 to -1	0.009
Difference between trend of post-Ebola vs pre-Ebola period ($\beta_3 + \beta_5$)	0	-1 to 1	1	0	0 to 0	0.657	0	0 to 0	0.431	0	0 to 1	0.503

Table 2 Pediatric admissions, pediatric deaths, and institutional deliveries at hospital level

	Pediatric admissions			Pediatric deaths			Institutional deliveries		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	1	-39 to 40	0.968	-1	-6 to 5	0.826	11	2 to 21	0.02
Difference between average of post-Ebola period vs Ebola period	133	92 to 174	<0.001	9	3 to 15	0.004	28	18 to 38	<0.001
Difference between average of post-Ebola period vs pre-Ebola period	134	98 - 170	<0.001	8	3 to 14	0.003	39	31 to 48	<0.001
Pre-Ebola period									
Number of events over pre-Ebola period (β_0)	46	10 to 82	0.011	7	2 to 12	0.007	27	19 to 34	<0.001
Trend in number over pre-Ebola period (β_1)	0	-2 to 2	0.808	0	0 to 0	0.641	0	0 to 0	0.42
Ebola period									
Average monthly change in number over Ebola period (β_2)	1	-48 to 50	0.955	1	-7 to 9	0.836	-12	-25 to 1	0.072
Difference between trend of Ebola period vs pre-Ebola period (β_3)	1	-8 to 10	0.823	0	-1 to 2	0.763	4	2 to 6	0.001
Post Ebola period									
Average monthly change in number over post-Ebola period (β_4)	53	5 to 100	0.029	6	-1 to 14	0.086	11	-1 to 22	0.064
Difference between trend of post-Ebola period vs Ebola period (β_5)	2	-7 to 10	0.702	0	-1 to 1	0.899	-3	-5 to -1	0.001
Difference between trend of post-Ebola vs pre-Ebola period ($\beta_3 + \beta_5$)	3	0 to 5	0.035	0	0 to 0	0.423	0	0 to 0	0.486

Table 3 Institutional delivery, ANC 1, ANC 4 and family planning at community level

	Institutional delivery			ANC 1			ANC 4			Family planning		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	148	99 to 196	<0.001	74	3 to 145	0.042	80	21 to 139	0.008	490	-92 to 1073	0.099
Difference between average of post-Ebola period vs Ebola period	-10	-59 to 39	0.695	-48	-122 to 26	0.2	23	-38 to 84	0.461	-262	-855 to 330	0.386
Difference between average of post-Ebola period vs pre-Ebola period	138	93 to 183	<0.001	26	-40 to 91	0.448	103	48 to 157	<0.001	228	-293 to 750	0.391
Pre Ebola period												
Number of events over pre-Ebola period (β_0)	688	643 to 732	<0.001	1062	1002 to 1121	<0.001	694	644 to 743	<0.001	2690	2187 to 3193	<0.001
Trend in number over pre-Ebola period (β1)	8	6 to 10	<0.001	7	4 to 10	<0.001	6	4 to 8	<0.001	69	42 to 95	<0.001
Ebola period												
Average monthly change in number over Ebola period (β_2)	-28	-90 to 34	0.382	-61	-161 to 40	0.238	-94	-176 to -11	0.027	-671	-1431 to 89	0.084
Difference between trend of Ebola period vs pre-Ebola period (β_3)	-1	-12 to 10	0.881	-5	-21 to 12	0.591	5	-8 to 19	0.437	-26	-156 to 104	0.692
Post Ebola period												
Average monthly change in number during post-Ebola period (β_4)	-25	-81 to 30	0.37	-5	-94 to 83	0.906	35	-37 to 109	0.343	-51	-759 to 657	0.888
Difference between trend of post-Ebola period vs Ebola period (β_5)	-7	-17 to 4	0.228	-2	-18 to 15	0.819	-13	-27 to 0	0.056	-59	-186 to 68	0.361
Difference between trend of post-Ebola vs pre-Ebola period ($\beta_3 + \beta_5$)	-7	-10 to -4	<0.001	-6	-10 to -3	<0.001	-8	-11 to -5	<0.001	-85	-119 to -51	<0.001

Community level: Pre-Ebola period

At community level, all the maternal health indicators in the months before Ebola showed a positive trend. There was a monthly average increase of 8 institutional deliveries (95% CI 6 to 10, p<0.001); a monthly average increase of 7 ANC 1 (95% CI 4 to 10, p<0.001) and 6 ANC 4 (95% CI 4 to 8, p<0.001), and a monthly average increase of 69 women accessing family planning services (95% CI 42 to 95, p<0.001) (Table 3; Figure 3).

Community level: Ebola vs pre-Ebola period

At community level, with the exception of family planning, the differences between averages of Ebola period vs pre-Ebola are statistically significant for all indicators: institutional deliveries (148, 95% CI 99 to 196, p <0.001), ANC 1 (74, 95 % CI 3 to 145, p = 0.042), and ANC 4 (80, 95% CI 21 to 139, p = 0.008). The average monthly change in number during the Ebola period was negative for the 4 indicators considered, but statistically significant only for the ANC 4 (-94, 95% -176 to -11, p = 0.027). There was no statistically significant difference between the Ebola period and pre-Ebola trends are for any of the indicators (Table 3; Figure 3).

Community level: Ebola vs post-Ebola period

At community level, the differences between averages and the difference between trends of the post Ebola vs Ebola period are not significant for any of the indicators considered (Table 3; Figure 3).

Community level: Post Ebola vs pre-Ebola period

The differences between averages of the post Ebola vs pre-Ebola are statistically significant, with an increase in institutional deliveries (138, 95% CI 93 to 183, p <0.001) and ANC 4 (103, 95% CI 48 to 157, p < 0.001) (Table 3; Figure 3). However, there is a negative difference between trends among the two periods, for all the variables considered: institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and family planning (-85, 95% CI -119 to -51, p <0.001) (Table 3; Figure 3).

Referral system: **Obstetric and paediatric results**

Between January 2015 and December 2017 there were 2,450 obstetric referrals. Of these, 1,574 (64%) were MDOC, which represent 70% of all the 2,233 MDOCs treated in the hospital over the same period. The baseline characteristics and reasons for MDOCs collected through the RS are reported on Table 4. At the same time, 4,671 paediatric patients were admitted in the hospital through the RS, representing 72% of the 6,518 total admission during the same period. Reasons for paediatric referrals are shown on Table 5.

Table 4 Baseline characteristics and reasons for MDOCs collected through RS, period 2015 - 2017

Age (years)	N	%
Mean	25,3	SD 7
12-19	442	28%
20-29	613	39%
30-39	464	29%
40+	43	3%
Unknown	12	1%
Number of previous deliveries		
0	474	30%
1 or 2	377	24%
3 or 4	292	19%
5 or 6	207	13%
7+	212	13%
Unknown	12	1%
MDOC treated		
Prolonged/obstructive labour	848	54%
Antepartum haemorrhage	195	12%
Severe pre-eclampsia/eclampsia	165	11%
Abortium complicatium	117	7%
Post-partum haemorrhage	157	10%
Ectopic pregnancy	24	2%
Rupture uterus	30	2%
Sepsis	38	2%
Total	1574	100%

Table 5 Reasons for paediatric RS, period 2015-2017*

Reason for referral	Number	%
Malaria	1540	30%
Anemia	910	18%
Pneumonia/ARI**	830	16%
Diarrhoea and vomiting	495	10%
Malnutrition	274	5%
Convulsion	186	4%
Hernia/Hydrocele	165	3%
Sepsis/Septicemia	127	2%
Dehydratation	48	1%
Burn	30	1%
Others	522	10%
Total	5127	100%

* For a number of patients, more than one suspected diagnosis for referral was reported; ** Acute Respiratory Infection

DISCUSSION

This study presents for the first time trends in utilization of MCH services before, during, and after Ebola, at hospital and community level from the country most heavily affected by the Ebola epidemic. It also presents data on the restructured and reorganised RS, which started immediately after the EVD outbreak. The study shows that there was a decrease in all MCH indicators and service uptake immediately after the onset of the outbreak, with a levelling or increase during the EVD period. In the post-Ebola period, all indicators (except for maternal deaths) showed an increase, in comparison with the pre-Ebola period. This was particularly marked at hospital level because the post Ebola reinforcement of the RS led to an increase in pediatric admissions, maternal admissions, and consequently a rise of institutional deliveries, C-sections, and MDOCs. In addition, while at the hospital level trends in the post-Ebola period are in line with the pre-Ebola, at community level there is a negative trend compared to the pre-Ebola period for all indicators taken into consideration. The study presents results in contrast to other studies that showed a decline in MCH services at facility and community levels in the Ebola and post-Ebola periods.[6 25 26]

Pre Ebola and Ebola periods

As extensively described in our previous reports,[18 27] a number of measures were put in place to control the Ebola epidemic in the Pujehun district which reduced the impact of the disease on mothers and children compared to other districts. During the EVD epidemic, the focus on vertical programmes was frequently associated with failures in basic management measures for controlling a disease outbreak. Rather than vertical interventions, the approach implemented in the Pujehun district focussed on all the components of the health system, beginning before the EVD crisis**.** A rapid response to the crisis by the local health authorities was implemented adopting public health measures before any other district in Sierra Leone.[28] The activities were mainly concentrated on keeping the health service open and properly functioning in order to reduce the collateral effects of the epidemic on routine health services. No health units in the Pujehun district were closed during the epidemic. Measures to empower community leaders and use culturally appropriate methods of communication helped to dispel community mistrust in the health services. At community level, a number of strategies were implemented such as the regular rotation of health facility staff, which strengthened teamwork and effective leadership. In Sierra Leone, healthcare workers based at community health centres may often work alone in isolated

centres with limited support from clinical colleagues or management. By rotating staff through the various facilities, they gain on the job training, peer support, and develop new working relationships. At the start of the Ebola epidemic, many expatriate healthcare workers in NGOs left Sierra Leone, negatively affecting care delivery and staff morale. The continued presence of international teams in the daily activities in Pujehun hospital and the acceptance of the professional risks by both national and international staff may have contributed to maintaining an attitude of 'normality' in an extremely stressful environment. This might also help to explain the population's positive receptiveness towards the health services.[18 27]

At community level, this report showed that family planning, ANC, and institutional deliveries, were affected only at the beginning of the Ebola outbreak with a small decrease in service utilization. In contrast, Jones et al., evaluated the number of antenatal and postnatal visits, institutional births, emergency obstetric care (EmOC), maternal deaths and stillbirths across 13 districts of Sierra Leone for 10 months during, and 12 months prior to the epidemic. They found that following the onset of the epidemic there was an 18% decrease in the number of women attending ANC visits and an 11% decrease in the number of women attending for birth at healthcare facilities.[14]

During the Ebola epidemic, the Pujehun hospital maintained C-sections and delivery volume at pre-Ebola levels. There was a stable number of patients attending the hospital during the Ebola outbreak, as shown by the number of maternal and pediatric admissions. The study of Brolin and colleagues focused on in-hospital deliveries and C-section volume in Sierra Leone. They showed that nationwide, albeit with substantial variation between districts, in-hospital deliveries and C-sections decreased by over 20% during the Ebola outbreak, mainly because of the closure of not-for-profit hospitals.[6] Brolin also noted that in general, at hospital level, in Sierra Leone those facilities that remained open performed about the same number of deliveries and C-sections after the onset of the EVD outbreak as they did before.[6] This seems to indicate that the decrease observed at national level was related to the closing of key health facilities. The number of Ebola cases was not uniform throughout districts in Sierra Leone and Pujehun was one of the least affected districts. The low number of cases may also have helped to maintain public confidence in service provision and uptake of services.[7 8]

Post Ebola period

There is a shortage of data in Sierra Leone and the other West Africa countries affected regarding the resumption of services after the epidemic. Pujehun district showed contrasting results at community level. Results of the post Ebola vs pre-Ebola show an increase of activities for institutional delivery and ANC 4. However, there is a negative trend among the two periods, for the variables taken into consideration, namely institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and family planning (-85, 95% CI -119 to -51, p <0.001). In 2017, the Pujehun district showed a coverage of 98% for ANC 1 (98% in 2013), 91% for ANC 4 (76% at national level in 2013) and 90% for institutional deliveries (62% in 2013).[29 30] The initial intervention carried out by DwA in the period 2012-2014 at the community level probably increased these percentages, with an initial growth of the trend that had been slowing down in the years 2016-2017.

A study by Camara et al. in a rural district of Guinea showed a considerable recovery gap in the post-Ebola period for ANC (37%) and institutional deliveries (34%).[25] Also Delamou et al. noted a significant reduction in the average number of ANC visits and institutional deliveries during the Ebola outbreak, in 6 districts of Guinea, and the overall post-outbreak trends did not suggest recovery.[26] By contrast, Wagenaar et al., which analysed 10 primary care indicators in Liberia, before, during, and after the Ebola outbreak, showed significant positive trends during the post-EVD period for ANC and institutional deliveries.[31] There are multifactorial and complex reasons for the decline of family planning in the Pujehun district. The activities that MoHS and DwA implemented from 2012 onwards were maintained during and after the EVD epidemic. However, a general decrease in the availability of healthcare personnel and international aid was observed. A possible stock-out of family planning methods has also been suggested as a reason for the decrease.[25] In addition, a reduction in demand for family planning in the post Ebola period could account for the decline of the service. Experiencing a disaster can trigger the desire to "rebuild" communities, reducing the need for family planning methods,[32] or communities may prefer traditional methods of contraception.[33] However, the reduction in family planning use in Pujehun district did not translate into an increase in institutional deliveries as occurred in neighbouring Liberia.[34] Although no further transmissions of Ebola took place in the Pujehun district after November 2015, the awareness of the ongoing transmission elsewhere in Sierra Leone, in Guinea and Liberia might have influenced health seeking behaviours.[35 36] However, this does not seem to have influenced other types of MCH services at community level. For comparison, the above

mentioned study of Camara et al. showed that the utilization of family planning declined by 51% during the Ebola outbreak but recovered in the post-Ebola period.[25]

At hospital level, the situation is different. In the post-Ebola period, there was a significant increase in the volumes of activities: pediatric and maternal admissions, MDOC cases, deliveries, and C-sections. This increase can be directly linked to the reorganization and strengthening of the RS immediately after the Ebola epidemic. Based on the 3 delays theory,[37] in Pujehun it was decided to tackle the second delay, a lack of accessibility to health services. The distance to the hospital as well as lack of accessible and affordable vehicles were recognized as significant barriers when attempting to access CEmONC services at the hospital.[38 39] The success of the RS service can be linked to the integration of the key components needed for a successful service, namely: i) a transport system which took account of the specific geographical characteristics of the district;[38] ii) an effective communication system with a call center in contact with all PHUs of the district, the ambulance drivers, and the hospital; iii) training of all the PHU staff on the recognition of obstetric emergencies and on the RS.[40 41] Several meetings were planned with local community leaders and religious leaders to raise awareness of the importance of giving birth in health facilities. Prohibitive costs have been shown to be a major factor in preventing women accessing health facilities during childbirth in Sierra Leone.[38 42 43] Meetings were also organised to inform the population that the service was free of charge, and to give reassurance that the ambulances carried no risk of Ebola infection to people using them. The increase in complicated cases treated at the hospital did not translate into an increase in maternal and pediatric deaths, reflecting positively on the quality of care provided. The maternity ward death rate remained around 1% throughout the 2012-2017 study period. The differences in average death rates during the period 2015-2017 among referred and not referred pediatric patients were 10.5% and 4.3% respectively. This showed that the pediatric RS works for the most critical cases able to reach the hospital in time.

CONCLUSIONS

There are a number of limitations to this study. The data refers to a single area of Sierra Leone and therefore our sample cannot be considered representative of the country as a whole. We defined our distinct period of EVD outbreak arbitrarily, from one month before the first case in the district to three months after the last case in the district. This was done because the EVD crisis affected areas of the country outside Pujehun prior to and after outbreak within Pujehun. The official end of the EVD epidemic for Sierra Leone was declared on March 17, 2016, and for the countries of

Guinea and Liberia was declared on June 1, 2016. Finally, our study assumed that no other interventions in addition to those described occurred concurrently with the Ebola epidemic.[18] Similarly, we assumed that no other substantial interventions in addition to the re-organisation of the RS happened in the post-Ebola period which would have affected the service trends that we observed. The strength of this study is that it uses data from a remote rural district in Sierra Leone, with a 6-year observational period. The pre, intra, and post-Ebola periods data, allowed a comparison between trends. DwA was working in this community before the outbreak began, which gave an advantage of knowledge of the setting when the epidemic began, which in turn facilitated mitigating measures to be put in place. In addition, this allowed a collection of data in a prospective way, reducing the potential bias in the accuracy of the data reported by other studies.[6 14 26 31]

During the EVD epidemic, the focus on vertical programmes was frequently associated with failures in basic management procedures for controlling a disease outbreak.[44] The approach implemented in the Pujehun district was not based on vertical interventions: on the contrary it worked on strengthening all the components of the health system - governance, human resources, community involvement - before, during and, after the epidemic. The strengthening of the health system in the district, compared to other districts, allowed the containment of the epidemic and, above all, to maintain and strengthen MCH services as shown by the data reported in the paper. Health facilities in the district, both at community and hospital level, were able to maintain their services during the epidemic, overcoming public fear of Ebola and lack of confidence in service providers, which led to the public staying away from facilities in other districts in Sierra Leone.[14] In post-crisis situations, "windows of opportunity" are opened for redirecting the policies of the national health systems, renovating specific sectors (e.g. human resources, epidemiological surveillance systems, financing, etc.) and renewing services/practices at the operational level.[45] In Pujehun the implementation of an RS immediately after the acute Ebola phase reduced delays in patients accessing care and enabled a significant improvement in all MCH indicators at hospital level. Other studies have also found that using this window of opportunity to introduce systems such as performance based financing can also produce positive outcomes.[46] As Sierra Leone continues its recovery, there is a need to quantify the impact of the outbreak on MCH care to guide long-term strategies for MHC services. This study provides evidence on strategies to increase the resilience of fragile healthcare services and the importance of NGOs and government collaboration to bring about change.

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Figure 1 Pediatric and maternal admissions at hospital level

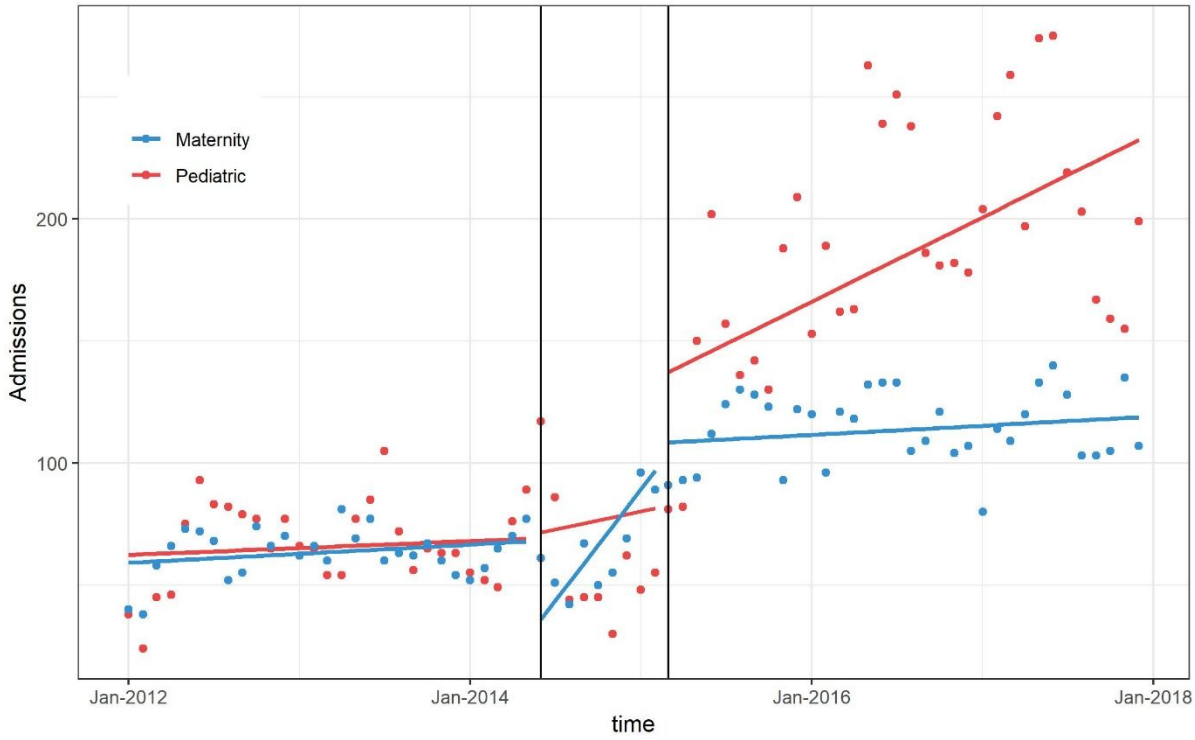


Figure 2 C-sections, deliveries, MDOCs, pediatric and maternal deaths at hospital level

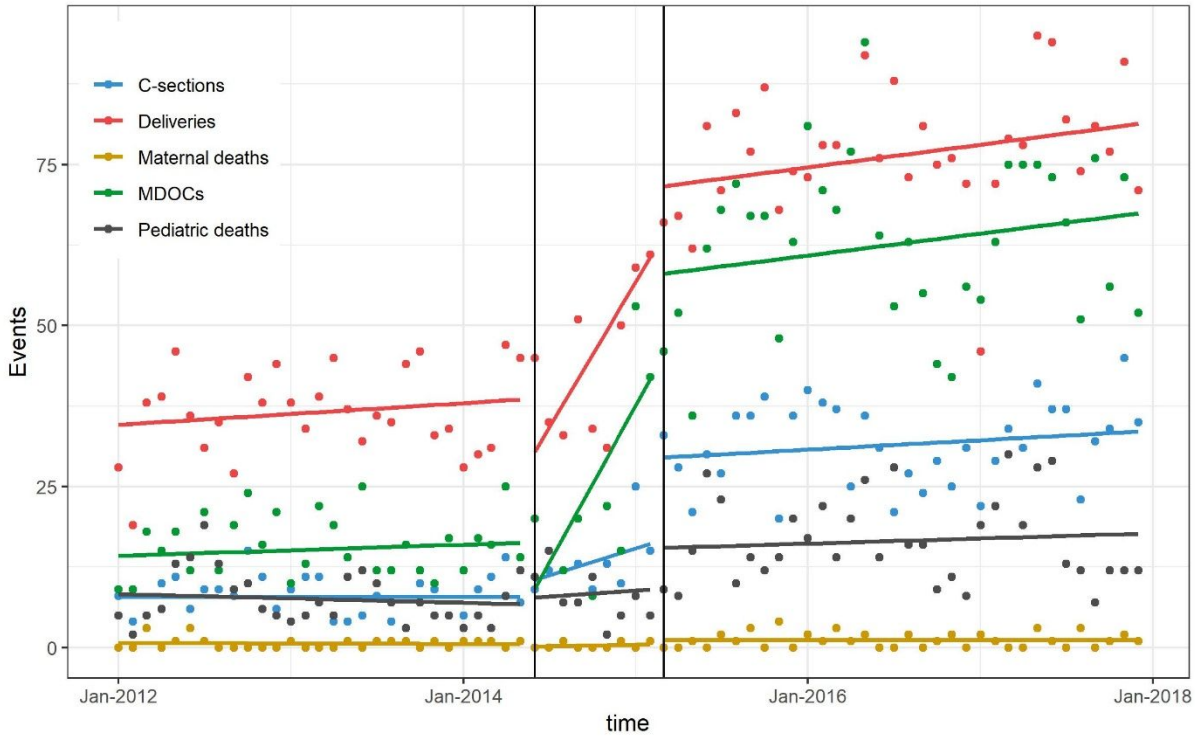
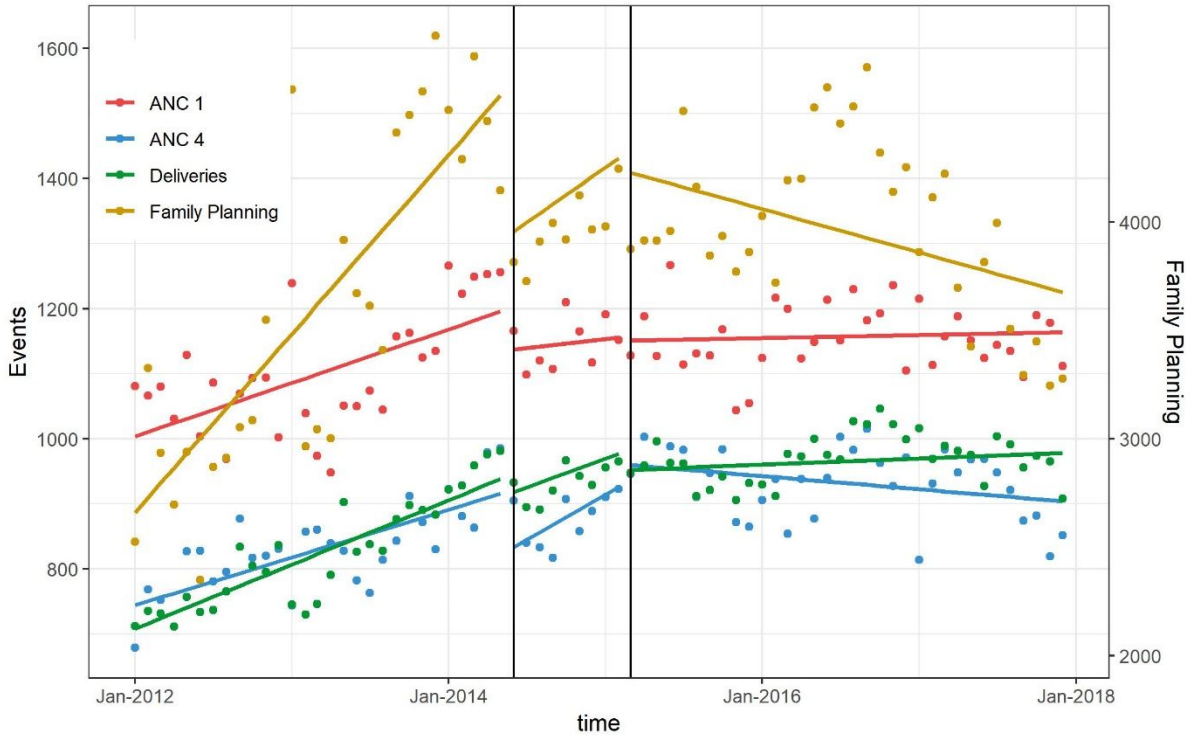


Figure 3 ANC 1, ANC 4, deliveries, and family planning at community level



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Impact of Ebola outbreak on reproductive health services in a rural district of Sierra Leone. A prospective observational study.

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ABSTRACT

Objectives To assess the trends concerning utilisation of maternal and child health (MCH) services before, during, and after the Ebola outbreak, quantifying the contribution of a reorganised referral system (RS).

Design A prospective observational study of MCH services.

Setting Pujehun district in Sierra Leone, 77 community health facilities and 1 hospital from 2012 to 2017.

Main outcome measures MCH utililization was evaluated by assessing: i) institutional deliveries, Cesarean-sections, paediatric and maternity admissions and deaths, and major direct obstetric complications (MDOCs), at hospital level; ii) antenatal care (ANC) 1 and 4, institutional delivery, and family planning, at community level. Contribution of a strengthened RS was also measured.

Results At hospital level, there is a significant difference between trends Ebola vs pre-Ebola for maternal admissions (7, 95% CI 4 to 11, p <0.001), MDOCs (4, 95% CI 1 to 7, p = 0.006), and institutional deliveries (4, 95% CI 2 to 6, p = 0.001). There is also a negative trend in the transition from Ebola to post Ebola for maternal admissions (-7, 95% CI -10 to -4, p <0.001), MDOCs (-4, 95% CI -7 to -1, p 0.009) and institutional deliveries (-3, 95% CI -5 to -1, p 0.001). The differences between trends pre-Ebola vs post-Ebola are only significant for pediatric admissions (3, 95% CI 0 to 5, p 0.035). At community level, the difference between trends Ebola vs pre-Ebola and Ebola vs post-Ebola are not significant for any indicators. The differences between trends pre-Ebola vs post-Ebola show a negative difference for institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and family planning (-85, 95% CI -119 to -51, p <0.001).

Conclusions A stronger health system compared to other districts in Sierra Leone and a strengthened RS enabled health facilities in Pujehun to maintain service provision and uptake during and after the Ebola epidemic.

Keywords: Ebola, Sierra Leone, Maternal and Child Health indicators, Referral system, Reproductive health service.

Strengths and limitations of this study

- The study uses data from a remote rural district in Sierra Leone, with a 6-year observational period. Data have been collected in a prospective way, reducing the potential bias in the accuracy of the data reported by other studies carried out in countries affected by Ebola.
- Data from pre, intra, and post-Ebola periods allowed comparisons between trends, something rarely carried out in countries heavily affected by Ebola.
- The data refers to a single area of Sierra Leone: the sample cannot be considered representative of the country as a whole.
- In addition to measures put in place to reduce the impact of the disease on mothers and children, Pujehun had far fewer Ebola cases than other districts, which may also have led to the utilization of health services.

INTRODUCTION

The 2014-2015 Ebola Virus Disease (EVD) outbreak was the most severe in history, mainly affecting three West African countries; Guinea, Sierra Leone and Liberia. Overall 28,616 people were infected of which 11,310 died and the outbreak was declared a global public health emergency by the WHO.[1] Of the three countries affected, Sierra Leone had the most confirmed cases (8,704), which accounted for 50% of all confirmed cases in West Africa, and 3,589 deaths.[2-4] All 14 districts in Sierra Leone were affected, but at different times and to varying degrees.[5] During the Ebola crisis the population's trust in the national health system declined in Sierra Leone, leading to an overall reduction in the use of health services, including reproductive, maternal, and child services.[6-8] Underlying factors for the decrease in the use of health services included fear of infection, for both healthcare workers and patients, the underlying fragility of the health systems, the reduced numbers of available health personnel, and the death of healthcare workers due to EVD.[9 10] It has been estimated that 30% of health workers who died of EVD in West Africa were maternal and child healthcare (MCH) providers.[11] However, there were considerable variations in the reduction of health service uptake when looked at by district level in Sierra Leone.[6 12-14] While districts such as Kambia, Port Loko and Bonthe showed large reductions in facility-based delivery (between 38-41%), the district of Pujehun showed only a 5% decrease in the same service. Similar geographic variations were seen in the reduction in antenatal care (ANC) visits.[12 13]

The number of confirmed EVD cases - and deaths - varied considerably by district. There were no more than 100 confirmed cases in both Bonthe and Pujehun, and up to 4,000 confirmed cases in both Port Loko and Bombali.[15] However, public fear of Ebola, regardless of the actual number of cases per district, may still have prevented many people from accessing services. The challenge of providing adequate levels of care during a humanitarian emergency such as the EVD crisis was further exacerbated by the weak health system in Sierra Leone, particularly in rural areas where the poor condition of the roads and high transport costs cause delays in accessing services, and contribute to increased maternal and neonatal mortality.[16]

Doctors with Africa (DwA) CUAMM is an Italian NGO working in Sierra Leone since 2012. It is present in the Pujehun district focusing on MCH care both at hospital and community level[17 18] In this paper, community level refers to Peripheral Health Units (PHUs), i.e. all health facilities outside the hospital. As described in our previous reports,[17 18] a number of measures were put in place to control the Ebola epidemic in the Pujehun district which reduced the impact of the disease on mothers and children compared to other districts. During this EVD epidemic, the predominantly vertical focus on

outbreak control was associated with failures in providing effective care for routine health needs.[19-21] In contrast, the approach implemented in the Pujehun district was not based on vertical actions and 'humanitarian response to health emergencies with a short half-life'.[21] Rather, it worked on strengthening all the components of the health system - governance, human resources, community involvement - before, during and, after the epidemic. A rapid response to the crisis by the local health authorities was implemented adopting public health measures before any other district in Sierra Leone.[22] The activities were mainly concentrated on keeping the health service open and properly functioning in order to reduce the collateral effects of the epidemic on routine health services. No health units in the Pujehun district were closed during the epidemic. Measures to empower community leaders and use culturally appropriate methods of communication helped to dispel community mistrust in the health services. At community level, a number of strategies were implemented such as the regular rotation of health facility staff, which strengthened teamwork and effective leadership. In Sierra Leone, healthcare workers based at community health centres may often work alone in isolated centres with limited support from clinical colleagues or management. By rotating staff through the various facilities, they gain on the job training, peer support, and develop new working relationships. At the start of the Ebola epidemic, many expatriate healthcare workers in NGOs left Sierra Leone, negatively affecting care delivery and staff morale. The continued presence of international teams in the daily activities in Pujehun hospital and the acceptance of the professional risks by both national and international staff may have contributed to maintaining an attitude of 'normality' in an extremely stressful environment. This might also help to explain the population's positive receptiveness towards the health services.[17 18]

Different types of referral systems (RSs) such as motorbikes were present in the country in the pre Ebola period to transport patients from the villages to the nearest health facility. Ambulances were also present in several districts with 73% of health facilities nationwide having a functioning RS, 59% of them consisting of an ambulance on call.[12 23] In the Pujehun district, the RS was barely functioning, only able to support the activity of a limited number of PHUs. The service was also entirely funded by the patients themselves, resulting in underutilization of the service. Utilization was further reduced during the outbreak, when the ambulances were identified by the population with the transport of Ebola infected patients, and their use occasioned fear and distrust. In January 2015, in collaboration with the Ministry of Health and Sanitation (MoHS) of Sierra Leone and UNICEF, DwA began the re-organisation and reinforcement of the RS, transferring pregnant women and pediatric cases from PHUs to the Pujehun hospital.

Our previous studies[18] provided information only on three MCH indicators, namely pediatric admissions, maternity admissions, and institutional deliveries; in addition it did not assess the trends in the post-EVD period. Existing studies examining the influence of EVD on MCH services targeted the outbreak and the immediate post-outbreak periods.[24-27] Understanding the trends in the use of MCH services before, during, and after the EVD outbreak will help to guide post-EVD interventions, increasing access to MCH services in rural Sierra Leone. This information will also be useful in preparing a more organised and structured RS. With this background, the aims of this study are: i) to assess trends in institutional deliveries, C-sections, paediatric and maternity admissions, paediatric and maternity deaths, and major direct obstetric complications (MDOCs), before, during, and after the EVD in the Pujehun hospital, thus complementing the results of the previous report which were limited to 3 MCH indicators; ii) to assess trends in ANC 1 and 4, institutional delivery, and family planning, at community level. This study was carried out in conjunction with the strengthening of an RS initiated a few weeks after the Pujehun district was declared Ebola-free.

METHODS

Setting

Sierra Leone has four provinces that are divided into 14 districts. Pujehun is one of four districts in the southern province (Figure 1). It has a population of approximately 375,000 inhabitants. The primary care network included 77 MoHS PHUs, 5 of which provide basic emergency obstetrics care (BEmOC). The secondary care system consists of the MoHS provided district hospital, which comprises the MCH complex, providing comprehensive emergency obstetric and newborn care (CEmONC) services. Connections between the community and health facilities are difficult because of the very poor condition of the roads. Furthermore, the district is divided by a major river (Moa River) and has a riverine area reachable only with boats, which further hinders access. The first case of Ebola in Pujehun district was reported on the 7th July 2014. The district was declared Ebola free on the 10th January 2015.[28] A total of 49 patients were registered with a case fatality rate of 85.7% (42/49).

Referral system

In the Pujehun district, two ambulances managed by the District Health Management Team (DHMT) were functioning in the pre Ebola period, but only 63% of the PHUs were able to use the service.[12 23] Emergency calls were not coordinated by the hospital and the transport costs were covered by the patients, dissuading many from using the service. During the outbreak, people came to associate the

ambulances with transporting Ebola infected patients, which further discouraged their use. A 24-h free-of-charge ambulance RS, transferring pregnant women with obstetric complications from the health centers to Pujehun hospital was implemented in January 2015. In the hospital a call center was established and the call center number was distributed to all the 77 PHUs. Private calls were considered only in the case of an emergency or if the staff of the PHU were not available. After confirming an emergency condition together with the PHU staff, the hospital midwife had the responsibility to authorize the referral. A nurse on duty from the maternity hospital accompanied the driver in each referral. Health personnel at hospital and PHUs levels were trained on Life Saving Skills – Emergency Obstetric and Newborn Care, including referral criteria and definition of MDOCs.[29]

Referrals were carried out by 3 ambulances, two positioned in the Pujehun MCH complex, and a third one in Jendema, bordering Liberia, on the opposite side of the Moa River. Around the Jendema area, 15 PHUs were located serving a population of approximately 80,000 inhabitants. Referrals in this area were made using the ambulances and by transferring patients at the river crossing point via a barge or a motor boat, depending on the flow rate of the river. Pediatric referrals were performed using private motor bikes available in the villages and hired from PHUs staff without the involvement of the call center. A referral form describing the clinical case and the justification for the referral was distributed to all the PHUs. The bike rider, after bringing the patient to the pediatric ward, delivered the referral form and received the reimbursement. For all patients carried to the hospital information was collected, including demographics, location, and the reason for contacting the RS. Community awareness activities were organized about the RS through meetings and radio discussions held by the DMHT, hospital health personnel, and local authorities.

Study design, population, and period

A prospective observational study using routinely collected health services data, from January 2012 to December 2017, was carried out. Three time periods were considered: pre- Ebola period (1st January 2012 – 30th May 2014); Ebola period (1st June 2014 – 28th February 2015); post- Ebola period (1st March 2015 – 31th December 2017). We considered the Ebola period from one month before the first confirmed case in the district (i.e. June 2014), to one month after the country being declared Ebola free (i.e. February 2015). This was done because in Sierra Leone the outbreak had started in other districts of the country before the first case registered in Pujehun and continued to affect other districts until November 2015. It is realistic to assume that public fear of potential EVD cases and lack of confidence in the health services persisted in the Pujehun population during that time.[14] In

addition, expanding the Ebola period enabled a full assessment of the impact of the disease with an adequate comparison with the two long periods before and after the Ebola epidemic.

Data collection

Data on MCH indicators was prospectively collected from hospital registers (maternity ward, delivery unit, pediatric ward, operating theatre). The following variables were collected on a monthly basis: 1) paediatrics admissions; 2) pediatric deaths; 3) maternity admissions; 4) maternal deaths; 5) deliveries; 6) C-sections; 7) MDOC cases. MDOC cases were collected using a dedicated database within the hospital and confirmed by a gynaecologist. All hospital maternal deaths were reviewed by DHMT and classified according to Maternal Death Surveillance and Response policy by MoHS. Paediatric deaths did not include stillbirths and early neonatal deaths, but only deaths of children admitted to the paediatric ward.

At community level, the following variables were collected from the local district Health Management Information System (HMIS): 1) family planning consultations per month; 2) deliveries per month; 3) ANC 1 per month; 4) ANC 4 per month. Different variables were collected from the two types of sites, based on the different services provided at community level (BEmOC) and at hospital level (CEmONC). Quarterly review meetings were organized with the staff in charge of the health facilities to address data discrepancies in the reports. Technical assistance was provided to the DHMT to improve timeliness, completeness, and accuracy of data regarding CEmOC and BEmONC services.

For the RS, data was collected from records of all of the study sites, including delivery registers, delivery logbooks, prenatal registers, referral registers, and death registers. Additional data was collected from the ambulance database and logbook. Records in the database were then validated by cross-checking the records with registers at the study sites.

Statistical analysis

For each indicator, a segmented seasonal autoregressive model of order 1 was estimated. The segments defined the three periods: before the EVD epidemic (January 2012 to May 2014), during the epidemic (June 2014 to February 2015), and after the epidemic (March 2015 to December 2017). The model for each indicator Y_t collected at hospital or community level was as follows: $Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \beta_4 Z_t + \beta_5 Z_t T_t + \beta_6 Month + \varepsilon_t$. β_0 estimates the number of individuals using the service at the beginning of the pre-Ebola period; β_1 estimates the average monthly change in the

number using the service over the pre-outbreak period; T_t is the time since the start of the study; β_2 represents the change in the level of service use that occurred in the period immediately after the EVD period (designated by indicator variable X_t); β_3 represents the difference between the trend in service use during the EVD outbreak compared to the pre-disease period; β_4 represents the change in service use that occurred in the period immediately after the end of the outbreak (post-outbreak period designated by indicator variable Z_t); β_5 is the difference between the trend in service use during the period after the Ebola virus disease outbreak compared with the period during the outbreak period; β_m represents a series of indicator variables for each calendar month, and t is the random error term. Overall trends across the periods and the comparisons among trends were calculated as follows: linear trend during the outbreak = $\beta_1 + \beta_3$; linear trend after the outbreak = $\beta_1 + \beta_3 + \beta_5$; and linear trend after the outbreak vs linear trend before the outbreak = $\beta_3 + \beta_5$. Average levels across the periods and their comparisons were calculated as follows: average during the outbreak = $\beta_0 + \beta_2$; average after the outbreak = $\beta_0 + \beta_2 + \beta_4$; and difference between after the outbreak and before the outbreak = $\beta_2 + \beta_4$. Differences were considered statistically significant at $p < 0.05$. The analysis was performed using R.[30] The full data analysis is available in Annex 1.

Patient involvement

No patients were involved in defining the research question or the outcome measures, nor were they involved in the design and implementation of the study. There are no plans to involve patients in the dissemination of the results.

RESULTS

Hospital level: Pre-Ebola period

At hospital level, for all indicators, the trend is stable during the pre Ebola period, without significant changes (Figure 2 and 3).

Hospital level: Ebola vs pre-Ebola period

At hospital level, the differences between Ebola period vs pre-Ebola averages show a statistically significant increase for institutional deliveries (11, 95% CI 2 to 21, p = 0.02) and for the reduction of maternal deaths (-1, 95% CI - 2 to 0, p = 0.042) (Table 1). There is also a statistically significant difference between the trend of Ebola period vs pre-Ebola period, for maternal admissions (7, 95%

CI 4 to 11, p <0.001), MDOCs (4, 95% CI 1 to 7, p = 0.006), and institutional deliveries (4, 95% CI 2 to 6, p = 0.001) (Figure 2 and 3).

Hospital level: Ebola vs post-Ebola period

At hospital level, the differences between averages of the post Ebola vs Ebola are statistically significant for all indicators: institutional deliveries, C-sections, paediatric and maternity admissions, paediatric and maternity deaths, and MDOCs (Table 1). There is also a negative trend in the transition from Ebola to post Ebola for maternal admissions (-7, 95% CI -10 to -4, p <0.001), MDOCs (-4, 95% CI -7 to -1, p 0.009) and institutional deliveries (-3, 95% CI -5 to -1, p 0.001) (Figure 2 and 3).

Hospital level: Pre-Ebola vs post-Ebola period

The differences between averages of the pre-Ebola vs post-Ebola periods are also statistically significant for all indicators, except for maternal deaths (Table 1). The differences between trends between pre-Ebola vs post-Ebola period are only significant for pediatric admissions (3, 95% CI 0 to 5, p 0.035) (Figure 2 and 3).

Table 1 MCH indicators at hospital and community level

Indicator	Difference between average of Ebola period vs pre-Ebola period			Difference between average of Ebola period vs post-Ebola period			Difference between average of pre-Ebola period vs post-Ebola period		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
HOSPITAL LEVEL									
Maternal admissions	7	-7 to 22	0.333	43	28 to 58	<0.001	50	37 to 64	<0.001
Maternal deaths	-1	-2 to 0	0.042	2	1 to 3	0.001	1	0 to 2	0.135
Institutional deliveries	11	2 to 21	0.02	28	18 to 38	<0.001	39	31 to 48	<0.001
C-sections	5	-1 to 11	0.13	15	8 to 21	<0.001	19	13 to 25	<0.001
MDOC	2	-11 to 14	0.782	41	30 to 54	<0.001	43	31 to 54	<0.001
Pediatric admissions	1	-39 to 40	0.968	133	92 to 174	<0.001	134	98 - 170	<0.001
Pediatric deaths	-1	-6 to 5	0.826	9	3 to 15	0.004	8	3 to 14	0.003
COMMUNITY LEVEL									
Institutional deliveries	148	99 to 196	<0.001	-10	-59 to 39	0.695	138	93 to 183	<0.001
ANC 1	74	3 to 145	0.042	-48	-122 to 26	0.2	26	-40 to 91	0.448
ANC 4	80	21 to 139	0.008	23	-38 to 84	0.461	103	48 to157	<0.001
Family planning	490	-92 to 1073	0.099	-262	-855 to 330	0.386	228	-293 to 750	0.391

Community level: Pre-Ebola period

At community level, all indicators in the months before Ebola showed a positive trend. There was a monthly average increase of 8 institutional deliveries (95% CI 6 to 10, p<0.001); a monthly average increase of 7 ANC 1 (95% CI 4 to 10, p<0.001) and 6 ANC 4 (95% CI 4 to 8, p<0.001), and a monthly average increase of 69 women accessing family planning services (95% CI 42 to 95, p<0.001) (Figure 4).

Community level: Ebola vs pre-Ebola period

At community level, with the exception of family planning, the differences between averages of Ebola period vs pre-Ebola are statistically significant for all indicators: institutional deliveries (148, 95% CI 99 to 196, p <0.001), ANC 1 (74, 95 % CI 3 to 145, p = 0.042), and ANC 4 (80, 95% CI 21 to 139, p = 0.008) (Table 1). The difference between trends (Figure 3) of the Ebola vs pre-Ebola period are not significant for any of the indicators considered (Figure 4).

Community level: Ebola vs post-Ebola period

At community level, the differences between averages (Table 1) and the difference between trends (Figure 4) of the Ebola vs post-Ebola period are not significant for any of the indicators considered.

Community level: Pre-Ebola vs post-Ebola period

The differences between averages of the pre-Ebola vs post-Ebola are statistically significant, with an increase in institutional deliveries (138, 95% CI 93 to 183, p <0.001) and ANC 4 (103, 95% CI 48 to 157, p < 0.001) (Table 1). However, there is a negative difference between trends among the two periods, for all the variables considered: institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and most significantly for family planning (-85, 95% CI -119 to -51, p <0.001) (Figure 4).

Referral system: **Obstetric and paediatric results**

Between January 2015 and December 2017 there were 2,450 obstetric referrals. Of these, 1,574 (64%) were MDOC, which represent 70% of all the 2,233 MDOCs treated in the hospital over the same period. The baseline characteristics and reasons for MDOCs collected through the RS are reported on Table 2. At the same time, 4,671 paediatric patients were admitted in the hospital through the RS,

representing 72% of the 6,518 total admission during the same period. Reasons for paediatric referrals are shown on Table 3.

Table 2 Baseline characteristics and reasons for MDOCs collected through RS, period 2015 - 2017

Age (years)	N	%
Mean	25,3	SD 7
12-19	442	28%
20-29	613	39%
30-39	464	29%
40+	43	3%
Unknown	12	1%
Number of previous deliveries		
0	474	30%
1 or 2	377	24%
3 or 4	292	19%
5 or 6	207	13%
7+	212	13%
Unknown	12	1%
MDOC treated		
Prolonged/obstructive labour	848	54%
Antepartum haemorrhage	195	12%
Severe pre-eclampsia/eclampsia	165	11%
Abortium complicatium	117	7%
Post-partum haemorrhage	157	10%
Ectopic pregnancy	24	2%
Rupture uterus	30	2%
Sepsis	38	2%
Total	1574	100%

Table 3 Reasons for paediatric RS, period 2015-2017*

Reason for referral	Number	%
Malaria	1540	30%
Anemia	910	18%
Pneumonia/ARI**	830	16%
Diarrhoea and vomiting	495	10%
Malnutrition	274	5%
Convulsion	186	4%
Hernia/Hydrocele	165	3%
Sepsis/Septicemia	127	2%
Dehydratation	48	1%
Burn	30	1%
Others	522	10%
Total	5127	100%

* For a number of patients, more than one suspected diagnosis for referral was reported; ** Acute Respiratory Infection.

DISCUSSION

This study presents for the first time trends in utilization of MCH services before, during, and after Ebola, at hospital and community level from the country most heavily affected by the Ebola epidemic. It also presents data on the restructured and reorganised RS, which started immediately after the EVD outbreak. The study shows that there was a decrease in all MCH indicators and service uptake immediately after the onset of the outbreak, with a levelling or increase during the EVD period. In the post-Ebola period, all indicators (except for maternal deaths) showed an increase, in comparison with the pre-Ebola period. This was particularly marked at hospital level because the post Ebola reinforcement of the RS led to an increase in pediatric admissions, maternal admissions, and consequently a rise of institutional deliveries, C-sections, and MDOCs. In addition, while at the hospital level trends in the post-Ebola period are in line with the pre-Ebola, at community level there is a negative trend compared to the pre-Ebola period for all indicators taken into consideration. The study presents results in contrast to other studies that showed a decline in MCH services in the Ebola and post-Ebola periods.[6 31 32]

Pre Ebola and Ebola periods

As mentioned above, the approach implemented in the Pujehun district [17 28] avoided vertical interventions only focused on the containment of the EVD epidemic. It worked on strengthening all the components of the health system - before, during, and long after the epidemic. This approach reduced the spread of infection and the impact of the disease on MCH services.[17 18] As shown by this paper, at community level family planning, ANC, and institutional deliveries, were affected only at the beginning of the Ebola outbreak with a small decrease in service utilization. In contrast, Jones et al., evaluated the number of antenatal and postnatal visits, institutional births, emergency obstetric care (EmOC), maternal deaths and stillbirths across 13 districts of Sierra Leone for 10 months during, and 12 months prior to the epidemic. They found that following the onset of the epidemic there was an 18% decrease in the number of women attending ANC visits and an 11% decrease in the number of women attending for birth at healthcare facilities.[14]

During the Ebola epidemic, the Pujehun hospital maintained C-sections and delivery volume at pre-Ebola levels. There was a stable number of patients attending the hospital during the Ebola outbreak, as shown by the number of maternal and pediatric admissions. The study of Brolin and colleagues focused on in-hospital deliveries and C-section volume in Sierra Leone. They showed that nationwide, albeit with substantial variation between districts, in-hospital deliveries and C-sections

decreased by over 20% during the Ebola outbreak, mainly because of the closure of not-for-profit hospitals.[6] Brolin also noted that in general, at hospital level, in Sierra Leone those facilities that remained open performed about the same number of deliveries and C-sections after the onset of the EVD outbreak as they did before.[6] This seems to indicate that the decrease observed at national level was related to the closing of key health facilities. The number of Ebola cases was not uniform throughout districts in Sierra Leone and Pujehun was one of the least affected districts. The low number of cases may also have helped to maintain public confidence in service provision and uptake of services.[7 8]

Post Ebola period

There is a shortage of data in Sierra Leone and the other West Africa countries affected regarding the resumption of services after the epidemic. Pujehun district showed contrasting results at community level. Results of the post Ebola vs pre-Ebola show an increase of activities for institutional delivery and ANC 4. However, there is a negative trend among the two periods, for the variables taken into consideration, namely institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and family planning (-85, 95% CI -119 to -51, p <0.001). In 2017, the Pujehun district showed a coverage of 98% for ANC 1 (98% in 2013), 91% for ANC 4 (76% at national level in 2013) and 90% for institutional deliveries (62% in 2013).[33 34] The initial intervention carried out by DwA in the period 2012-2014 at the community level probably increased these percentages, with an initial growth of the trend that had been slowing down in the years 2016-2017. Possible explanations for this may include: bypassing, i.e. using alternative health care instead of free or subsidized public clinics; increased opportunities to get transport to seek healthcare in neighbouring districts; reduced demand for MCH services at community level; and reduced quality of MCH services at PHUs.

A study by Camara et al. in a rural district of Guinea showed a considerable recovery gap in the post-Ebola period for ANC (37%) and institutional deliveries (34%).[31] Also Delamou et al. noted a significant reduction in the average number of ANC visits and institutional deliveries during the Ebola outbreak, in 6 districts of Guinea, and the overall post-outbreak trends did not suggest recovery.[32] By contrast, Wagenaar et al., which analysed 10 primary care indicators in Liberia, before, during, and after the Ebola outbreak, showed significant positive trends during the post-EVD period for ANC and institutional deliveries.[35]

There are multifactorial and complex reasons for the decline of family planning in the Pujehun district. The activities that MoHS and DwA implemented from 2012 onwards were maintained during and after the EVD epidemic. However, a general decrease in the availability of healthcare personnel and international aid was observed and this could be a factor in the family planning decline. A possible stock-out of family planning methods has also been suggested as a reason for the decrease.[25] In addition, a reduction in demand for family planning in the post Ebola period could account for the decline of the service. Experiencing a disaster can trigger the desire to "rebuild" communities, reducing the need for family planning methods,[36] or communities may prefer traditional methods of contraception.[37] However, the reduction in family planning use in Pujehun district did not translate into an increase in institutional deliveries as occurred in neighbouring Liberia.[38] Although no further transmissions of Ebola took place in the Pujehun district after November 2015, the awareness of the ongoing transmission elsewhere in Sierra Leone, in Guinea and Liberia might have influenced health seeking behaviours.[39 40] However, this does not seem to have influenced other types of MCH services at community level. For comparison, the above mentioned study of Camara et al. showed that the utilization of family planning declined by 51% during the Ebola outbreak but recovered in the post-Ebola period.[31]

At hospital level, the situation is different. In the post-Ebola period, there was a significant increase in the volumes of activities: pediatric and maternal admissions, MDOC cases, deliveries, and C-sections. This increase can be directly linked to the reorganization and strengthening of the RS immediately after the Ebola epidemic. Based on the 3 delays theory,[41] in Pujehun it was decided to tackle the second delay, a lack of accessibility to health services. The distance to the hospital as well as lack of accessible and affordable vehicles were recognized as significant barriers when attempting to access CEmONC services at the hospital.[42 43] The success of the RS service can be linked to the integration of the key components needed for a successful service, namely: i) a transport system which took account of the specific geographical characteristics of the district;[42] ii) an effective communication system with a call center in contact with all PHUs of the district, the ambulance drivers, and the hospital; iii) training of all the PHU staff on the recognition of obstetric emergencies and on the RS.[44 45] Several meetings were planned with local community leaders and religious leaders to raise awareness of the importance of giving birth in health facilities. Prohibitive costs have been shown to be a major factor in preventing women accessing health facilities during childbirth in Sierra Leone.[42 46 47] Meetings were also organised to inform the population that the service was free of charge, and to give reassurance that the ambulances carried no risk of Ebola infection to people using

them. The increase in complicated cases treated at the hospital did not translate into an increase in maternal and pediatric deaths, reflecting positively on the quality of care provided. The maternity ward death rate remained around 1% throughout the 2012-2017 study period. The differences in average death rates during the period 2015-2017 among referred and not referred pediatric patients were 10.5% and 4.3% respectively. This showed that the pediatric RS works for the most critical cases able to reach the hospital in time.

CONCLUSIONS

There are a number of contextual factors and limitations that should be taken into account in the analysis of the results of this study. The data refers to a single area of Sierra Leone and therefore our sample cannot be considered representative of the country as a whole. We defined our distinct period of EVD outbreak arbitrarily, from one month before the first case in the district to three months after the last case in the district. This was done because the EVD crisis affected areas of the country outside Pujehun prior to and after outbreak within Pujehun. The official end of the EVD epidemic for Sierra Leone was declared on March 17, 2016, and for the countries of Guinea and Liberia was declared on June 1, 2016. Finally, our study assumed that no other interventions in addition to those described occurred concurrently with the Ebola epidemic.[18] Similarly, we assumed that no other substantial interventions in addition to the re-organisation of the RS happened in the post-Ebola period which would have affected the service trends that we observed. The Pujehun district had 49 confirmed EVD cases. This number is much lower than in other districts. If it is true that the fear of Ebola may have prevented people from accessing health services, the small number of EVD cases in the community may have also raised confidence, leading to the increase of utilization rates after the initial drop. The strength of this study is that it uses data from a remote rural district in Sierra Leone, with a 6-year observational period. The pre, intra, and post-Ebola periods data, allowed a comparison between trends. DwA was working in this community before the outbreak began, which gave an advantage of knowledge of the setting when the epidemic began, which in turn facilitated mitigating measures to be put in place. In addition, this allowed a collection of data in a prospective way, reducing the potential bias in the accuracy of the data reported by other studies.[6 14 32 35]

Failures in providing effective health care are associated with a chiefly vertical focus on outbreak control.[19-21] The approach implemented in the Pujehun district worked on strengthening all the components of the health system - governance, human resources, community involvement - before, during and, after the epidemic.

The strengthening of the health system in the district, compared to other districts, allowed the containment of the epidemic and, above all, to maintain and strengthen MCH services as shown by the data reported in the paper. Health facilities in the district, both at community and hospital level, were able to maintain their services during the epidemic, overcoming public fear of Ebola and lack of confidence in service providers, which led to the public staying away from facilities in other districts in Sierra Leone.[14] In post-crisis situations, "windows of opportunity" are opened for redirecting the policies of the national health systems, renovating specific sectors (e.g. human resources, epidemiological surveillance systems, financing, etc.) and renewing services/practices at the operational level.[48] In Pujehun the implementation of an RS immediately after the acute Ebola phase reduced delays in patients accessing care and enabled a significant improvement in all MCH indicators at hospital level. Other studies have also found that using this window of opportunity to introduce systems such as performance based financing can also produce positive outcomes.[49] As Sierra Leone continues its recovery, there is a need to quantify the impact of the outbreak on MCH care to guide long-term strategies for MHC services. This study provides evidence on strategies to increase the resilience of fragile healthcare services and the importance of NGOs and government collaboration to bring about change.

Figure 1 Study area, the Pujehun district in Sierra Leone.

Figure 2 Maternal and pediatric admissions at hospital level.

Figure 3 C-sections, deliveries, MDOCs, pediatric and maternal deaths at hospital level.

Figure 4 ANC 1, ANC 4, deliveries, and family planning at community level.

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Disclaimer The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the affiliated organisations.

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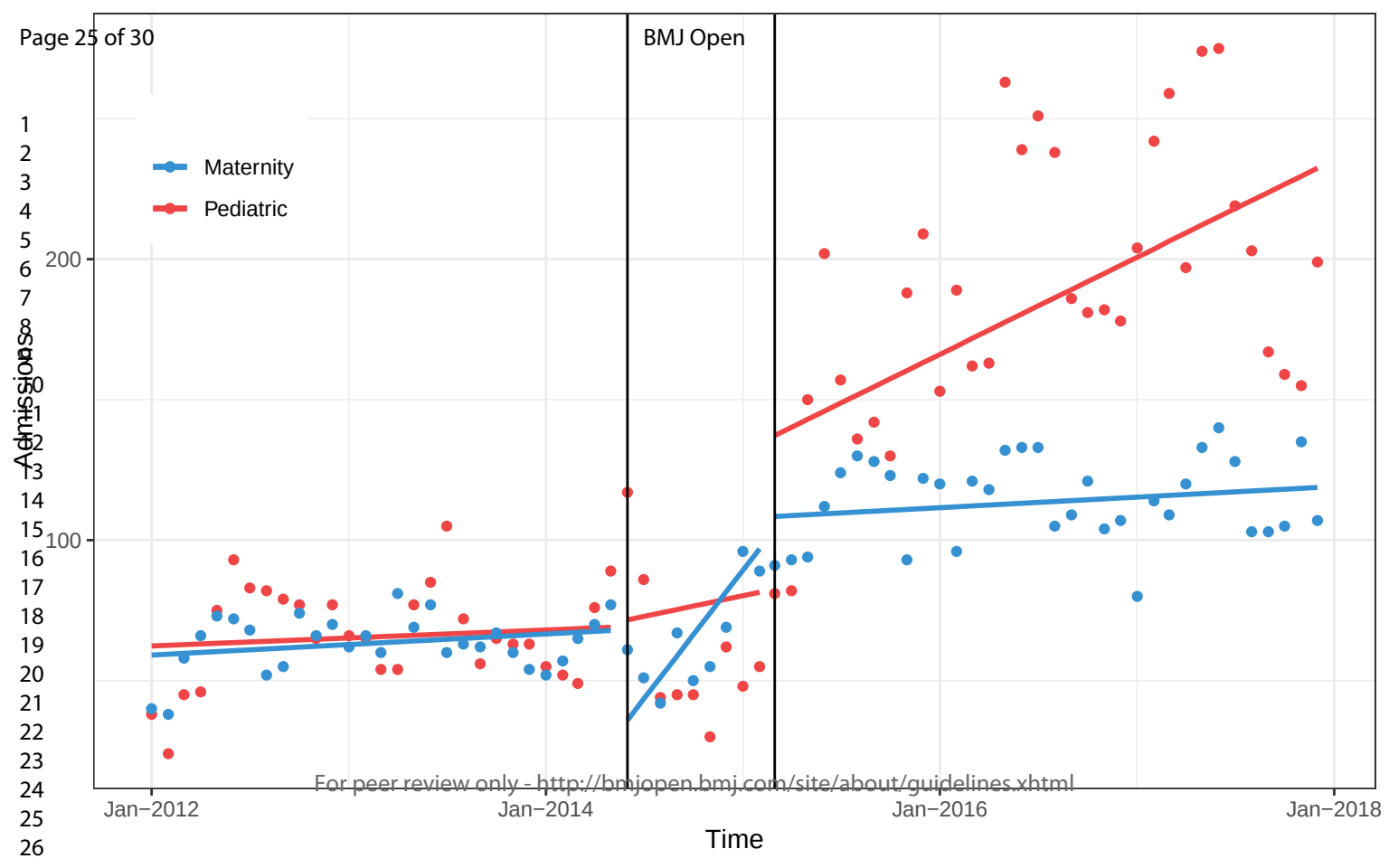

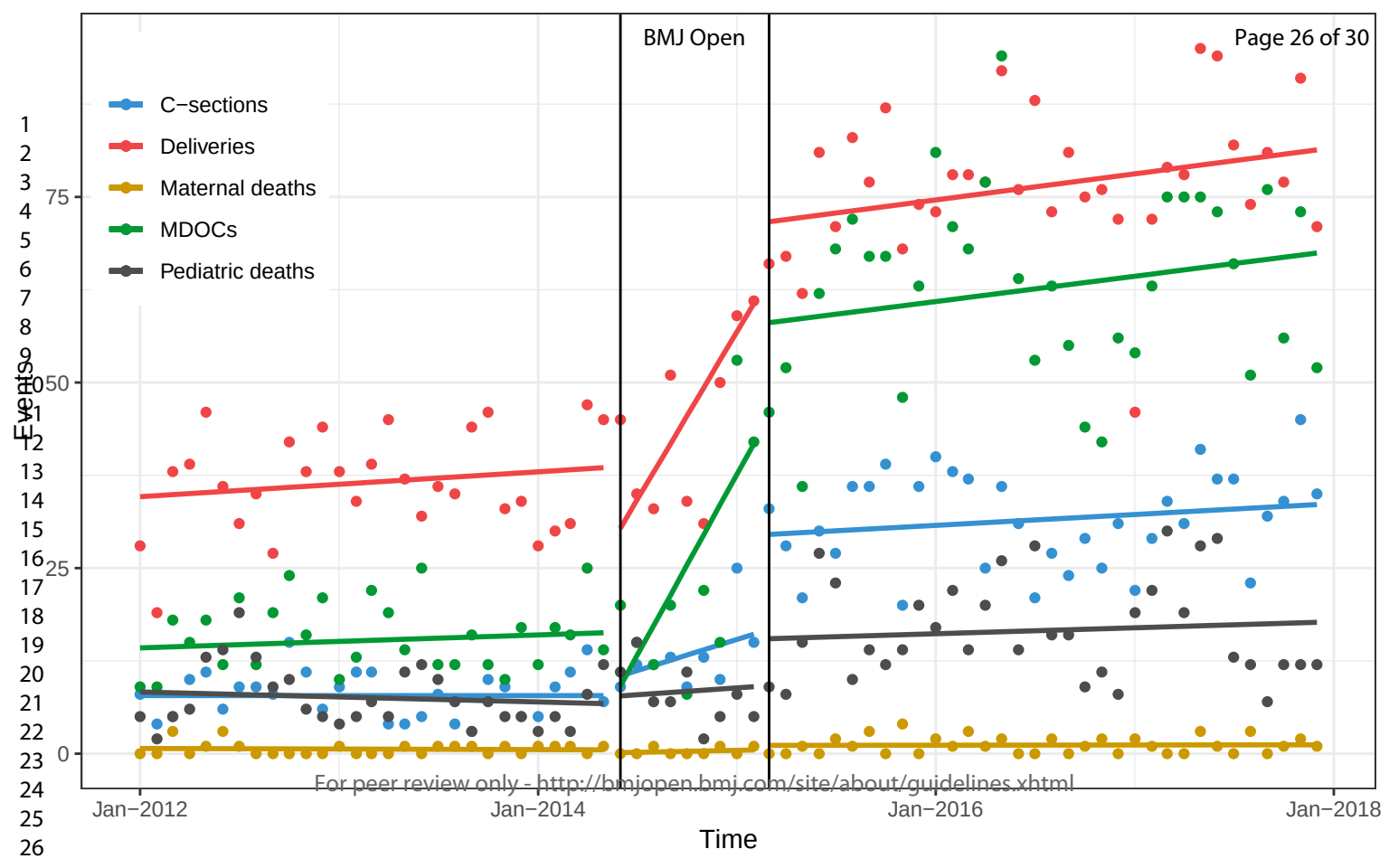

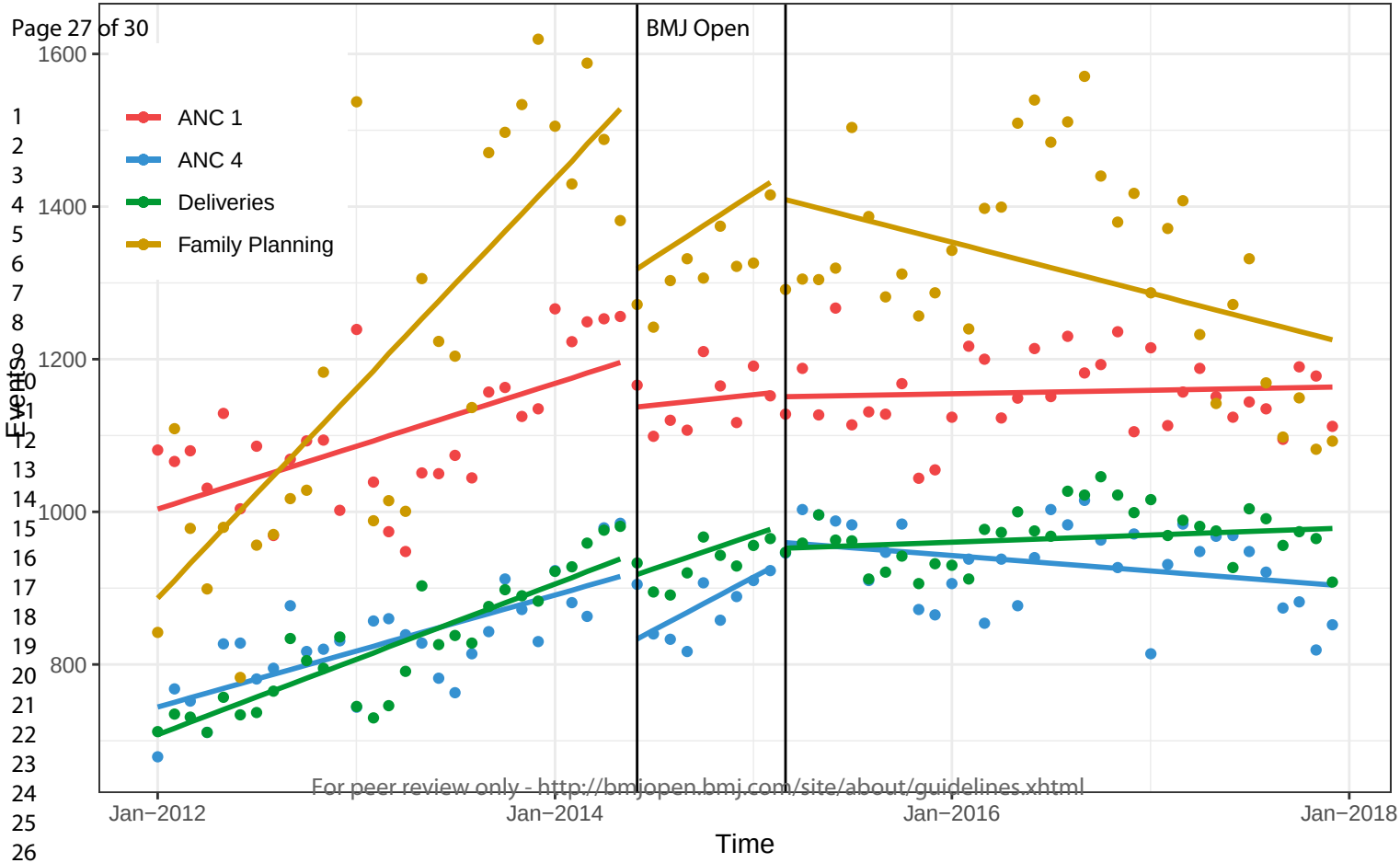

Maternal admissions, maternal deaths, C-sections, and MDOCs at hospital level.

	Maternal admissions			Maternal deaths			C-sections			MDOC		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	7	-7 to 22	0.333	-1	-2 to 0	0.042	5	-1 to 11	0.13	2	-11 to 14	0.782
Difference between average of post-Ebola period vs Ebola period	43	28 to 58	<0.001	2	1 to 3	0.001	15	8 to 21	<0.001	41	30 to 54	<0.001
Difference between average of post-Ebola period vs pre-Ebola period	50	37 to 64	<0.001	1	0 to 2	0.135	19	13 to 25	<0.001	43	31 to 54	<0.001
Pre-Ebola period												
Number of events over pre-Ebola period (β_0)	49	37 to 61	<0.001	1	0 to 2	0.026	9	4 to 14	0.001	16	5 to 26	0.003
Trend in number over pre-Ebola period (β_1)	0	0 to 1	0.281	0	0 to 0	0.677	0	-0 to 0	0.999	0	0 to 0.5	0.768
Ebola period												
Average monthly change in number over Ebola period (β_2)	-40	-60 to -19	<0.001	0	-2 to 0	0.480	2	-7 to 11	0.668	-11	-29 to 6	0.207
Difference between trend of Ebola period vs pre-Ebola period (β_3)	7	4 to 11	<0.001	0	0 to 0	0.605	1	-1 to 2	0.346	4	1 to 7	0.006
Post-Ebola period												
Average monthly change in number during post-Ebola period (β_4)	11	-7 to 30	0.23	1	0 to 2	0.258	13	5 to 21	0.001	16	0 to 32	0.044
Difference between trend of post-Ebola period vs Ebola period (β_5)	-7	-10 to -4	<0.001	0	0 to 0	0.665	-1	-2 to 0.8	0.433	-4	-7 to -1	0.009
Difference between trend of post-Ebola vs pre-Ebola period ($\beta_3 + \beta_5$)	0	-1 to 1	1	0	0 to 0	0.657	0	0 to 0	0.431	0	0 to 1	0.503

Pediatric admissions, pediatric deaths, and institutional deliveries at hospital level.

	Pediatric admissions			Pediatric deaths			Institutional deliveries		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	1	-39 to 40	0.968	-1	-6 to 5	0.826	11	2 to 21	0.02
Difference between average of post-Ebola period vs Ebola period	133	92 to 174	<0.001	9	3 to 15	0.004	28	18 to 38	<0.001
Difference between average of post-Ebola period vs pre-Ebola period	134	98 - 170	<0.001	8	3 to 14	0.003	39	31 to 48	<0.001
Pre-Ebola period									
Number of events over pre-Ebola period (β_0)	46	10 to 82	0.011	7	2 to 12	0.007	27	19 to 34	<0.001
Trend in number over pre-Ebola period (β_1)	0	-2 to 2	0.808	0	0 to 0	0.641	0	0 to 0	0.42
Ebola period									
Average monthly change in number over Ebola period (β_2)	1	-48 to 50	0.955	1	-7 to 9	0.836	-12	-25 to 1	0.072
Difference between trend of Ebola period vs pre-Ebola period (β_3)	1	-8 to 10	0.823	0	-1 to 2	0.763	4	2 to 6	0.001
Post Ebola period									
Average monthly change in number over post-Ebola period (β_4)	53	5 to 100	0.029	6	-1 to 14	0.086	11	-1 to 22	0.064
Difference between trend of post-Ebola period vs Ebola period (β_5)	2	-7 to 10	0.702	0	-1 to 1	0.899	-3	-5 to -1	0.001
Difference between trend of post-Ebola vs pre-Ebola period ($\beta_3 + \beta_5$)	3	0 to 5	0.035	0	0 to 0	0.423	0	0 to 0	0.486

Institutional delivery, ANC 1, ANC 4 and family planning at community level.

	Institutional delivery			ANC 1			ANC 4			Family planning		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	148	99 to 196	<0.001	74	3 to 145	0.042	80	21 to 139	0.008	490	-92 to 1073	0.099
Difference between average of post-Ebola period vs Ebola period	-10	-59 to 39	0.695	-48	-122 to 26	0.2	23	-38 to 84	0.461	-262	-855 to 330	0.386
Difference between average of post-Ebola period vs pre-Ebola period	138	93 to 183	<0.001	26	-40 to 91	0.448	103	48 to 157	<0.001	228	-293 to 750	0.391
Pre Ebola period												
Number of events over pre-Ebola period (β_0)	688	643 to 732	<0.001	1062	1002 to 1121	<0.001	694	644 to 743	<0.001	2690	2187 to 3193	<0.001
Trend in number over pre-Ebola period (β1)	8	6 to 10	<0.001	7	4 to 10	<0.001	6	4 to 8	<0.001	69	42 to 95	<0.001
Ebola period												
Average monthly change in number over Ebola period (β_2)	-28	-90 to 34	0.382	-61	-161 to 40	0.238	-94	-176 to -11	0.027	-671	-1431 to 89	0.084
Difference between trend of Ebola period vs pre-Ebola period (β_3)	-1	-12 to 10	0.881	-5	-21 to 12	0.591	5	-8 to 19	0.437	-26	-156 to 104	0.692
Post Ebola period												
Average monthly change in number during post-Ebola period (β_4)	-25	-81 to 30	0.37	-5	-94 to 83	0.906	35	-37 to 109	0.343	-51	-759 to 657	0.888
Difference between trend of post-Ebola period vs Ebola period (β_5)	-7	-17 to 4	0.228	-2	-18 to 15	0.819	-13	-27 to 0	0.056	-59	-186 to 68	0.361
Difference between trend of post-Ebola vs pre-Ebola period (β3 + β5)	-7	-10 to -4	<0.001	-6	-10 to -3	<0.001	-8	-11 to -5	<0.001	-85	-119 to -51	<0.001

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6	
Objectives	3	State specific objectives, including any prespecified hypotheses	6	
Methods				
Study design	4	Present key elements of study design early in the paper	7	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8	
Participants	6	(*a*) *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8	
Bias	9	Describe any efforts to address potential sources of bias	16-17	
Study size	10	Explain how the study size was arrived at		

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy NA	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9-12
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	9-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-11

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Keywords:	PAEDIATRICS, Public health < INFECTIOUS DISEASES, Community gynaecology < GYNAECOLOGY

Impact of Ebola outbreak on reproductive health services in a rural district of Sierra Leone. A prospective observational study.

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ABSTRACT

Objectives To assess the trends concerning utilisation of maternal and child health (MCH) services before, during, and after the Ebola outbreak, quantifying the contribution of a reorganised referral system (RS).

Design A prospective observational study of MCH services.

Setting Pujehun district in Sierra Leone, 77 community health facilities and 1 hospital from 2012 to 2017.

Main outcome measures MCH utililization was evaluated by assessing: i) institutional deliveries, Cesarean-sections, paediatric and maternity admissions and deaths, and major direct obstetric complications (MDOCs), at hospital level; ii) antenatal care (ANC) 1 and 4, institutional delivery, and family planning, at community level. Contribution of a strengthened RS was also measured.

Results At hospital level, there is a significant difference between trends Ebola vs pre-Ebola for maternal admissions (7, 95% CI 4 to 11, p <0.001), MDOCs (4, 95% CI 1 to 7, p = 0.006), and institutional deliveries (4, 95% CI 2 to 6, p = 0.001). There is also a negative trend in the transition from Ebola to post Ebola for maternal admissions (-7, 95% CI -10 to -4, p <0.001), MDOCs (-4, 95% CI -7 to -1, p 0.009) and institutional deliveries (-3, 95% CI -5 to -1, p 0.001). The differences between trends pre-Ebola vs post-Ebola are only significant for pediatric admissions (3, 95% CI 0 to 5, p 0.035). At community level, the difference between trends Ebola vs pre-Ebola and Ebola vs post-Ebola are not significant for any indicators. The differences between trends pre-Ebola vs post-Ebola show a negative difference for institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and family planning (-85, 95% CI -119 to -51, p <0.001).

Conclusions A stronger health system compared to other districts in Sierra Leone and a strengthened RS enabled health facilities in Pujehun to maintain service provision and uptake during and after the Ebola epidemic.

Keywords: Ebola, Sierra Leone, Maternal and Child Health indicators, Referral system, Reproductive health service.

Strengths and limitations of this study

- The study uses data from a remote rural district in Sierra Leone, with a 6-year observational period. Data have been collected in a prospective way, reducing the potential bias in the accuracy of the data reported by other studies carried out in countries affected by Ebola.
- Data from pre, intra, and post-Ebola periods allowed comparisons between trends, something rarely carried out in countries heavily affected by Ebola.
- The data refers to a single area of Sierra Leone: the sample cannot be considered representative of the country as a whole.
- In addition to measures put in place to reduce the impact of the disease on mothers and children, Pujehun had far fewer Ebola cases than other districts, which may also have led to the utilization of health services.

INTRODUCTION

The 2014-2015 Ebola Virus Disease (EVD) outbreak was the most severe in history, mainly affecting three West African countries; Guinea, Sierra Leone and Liberia. Overall 28,616 people were infected of which 11,310 died and the outbreak was declared a global public health emergency by the WHO.[1] Of the three countries affected, Sierra Leone had the most confirmed cases (8,704), which accounted for 50% of all confirmed cases in West Africa, and 3,589 deaths.[2-4] All 14 districts in Sierra Leone were affected, but at different times and to varying degrees.[5] During the Ebola crisis the population's trust in the national health system declined in Sierra Leone, leading to an overall reduction in the use of health services, including reproductive, maternal, and child services.[6-8] Underlying factors for the decrease in the use of health services included fear of infection, for both healthcare workers and patients, the underlying fragility of the health systems, the reduced numbers of available health personnel, and the death of healthcare workers due to EVD.[9 10] It has been estimated that 30% of health workers who died of EVD in West Africa were maternal and child healthcare (MCH) providers.[11] However, there were considerable variations in the reduction of health service uptake when looked at by district level in Sierra Leone.[6 12-14] While districts such as Kambia, Port Loko and Bonthe showed large reductions in facility-based delivery (between 38-41%), the district of Pujehun showed only a 5% decrease in the same service. Similar geographic variations were seen in the reduction in antenatal care (ANC) visits.[12 13]

The number of confirmed EVD cases - and deaths - varied considerably by district. There were no more than 100 confirmed cases in both Bonthe and Pujehun, and up to 4,000 confirmed cases in both Port Loko and Bombali.[15] However, public fear of Ebola, regardless of the actual number of cases per district, may still have prevented many people from accessing services. The challenge of providing adequate levels of care during a humanitarian emergency such as the EVD crisis was further exacerbated by the weak health system in Sierra Leone, particularly in rural areas where the poor condition of the roads and high transport costs cause delays in accessing services, and contribute to increased maternal and neonatal mortality.[16]

Doctors with Africa (DwA) CUAMM is an Italian NGO working in Sierra Leone since 2012. It is present in the Pujehun district focusing on MCH care both at hospital and community level[17 18] In this paper, community level refers to Peripheral Health Units (PHUs), i.e. all health facilities outside the hospital. As described in our previous reports,[17 18] a number of measures were put in place to control the Ebola epidemic in the Pujehun district which might have reduced the impact of the disease on mothers and children compared to other districts. During this EVD epidemic, the predominantly

vertical focus on outbreak control was associated with failures in providing effective care for routine health needs.[19-21] In contrast, the approach implemented in the Pujehun district was not based on vertical actions and 'humanitarian response to health emergencies with a short half-life'.[21] Rather, it worked on strengthening all the components of the health system - governance, human resources, community involvement - before, during and, after the epidemic. A rapid response to the crisis by the local health authorities was implemented adopting public health measures before any other district in Sierra Leone.[22] The activities were mainly concentrated on keeping the health service open and properly functioning in order to reduce the collateral effects of the epidemic on routine health services. No health units in the Pujehun district were closed during the epidemic. Measures to empower community leaders and use culturally appropriate methods of communication helped to dispel community mistrust in the health services. At community level, a number of strategies were implemented such as the regular rotation of health facility staff, which strengthened teamwork and effective leadership. In Sierra Leone, healthcare workers based at community health centres may often work alone in isolated centres with limited support from clinical colleagues or management. By rotating staff through the various facilities, they gain on the job training, peer support, and develop new working relationships. At the start of the Ebola epidemic, many expatriate healthcare workers in NGOs left Sierra Leone, negatively affecting care delivery and staff morale. The continued presence of international teams in the daily activities in Pujehun hospital and the acceptance of the professional risks by both national and international staff may have contributed to maintaining an attitude of 'normality' in an extremely stressful environment. This might also help to explain the population's positive receptiveness towards the health services.[17 18]

Different types of referral systems (RSs) such as motorbikes were present in the country in the pre Ebola period to transport patients from the villages to the nearest health facility. Ambulances were also present in several districts with 73% of health facilities nationwide having a functioning RS, 59% of them consisting of an ambulance on call.[12 23] In the Pujehun district, the RS was barely functioning, only able to support the activity of a limited number of PHUs. The service was also entirely funded by the patients themselves, resulting in underutilization of the service. Utilization was further reduced during the outbreak, when the ambulances were identified by the population with the transport of Ebola infected patients, and their use occasioned fear and distrust. In January 2015, in collaboration with the Ministry of Health and Sanitation (MoHS) of Sierra Leone and UNICEF, DwA began the re-organisation and reinforcement of the RS, transferring pregnant women and pediatric cases from PHUs to the Pujehun hospital.

Our previous studies[18] provided information only on three MCH indicators, namely pediatric admissions, maternity admissions, and institutional deliveries; in addition it did not assess the trends in the post-EVD period. Existing studies examining the influence of EVD on MCH services targeted the outbreak and the immediate post-outbreak periods.[24-27] Understanding the trends in the use of MCH services before, during, and after the EVD outbreak will help to guide post-EVD interventions, increasing access to MCH services in rural Sierra Leone. This information will also be useful in preparing a more organised and structured RS. With this background, the aims of this study are: i) to assess trends in institutional deliveries, C-sections, paediatric and maternity admissions, paediatric and maternity deaths, and major direct obstetric complications (MDOCs), before, during, and after the EVD in the Pujehun hospital, thus complementing the results of the previous report which were limited to 3 MCH indicators; ii) to assess trends in ANC 1 and 4, institutional delivery, and family planning, at community level. This study was carried out in conjunction with the strengthening of an RS initiated a few weeks after the Pujehun district was declared Ebola-free.

METHODS

Setting

Sierra Leone has four provinces that are divided into 14 districts. Pujehun is one of four districts in the southern province (Figure 1). It has a population of approximately 375,000 inhabitants. The primary care network included 77 MoHS PHUs, 5 of which provide basic emergency obstetrics care (BEmOC). The secondary care system consists of the MoHS provided district hospital, which comprises the MCH complex, providing comprehensive emergency obstetric and newborn care (CEmONC) services. Connections between the community and health facilities are difficult because of the very poor condition of the roads. Furthermore, the district is divided by a major river (Moa River) and has a riverine area reachable only with boats, which further hinders access. The first case of Ebola in Pujehun district was reported on the 7th July 2014. The district was declared Ebola free on the 10th January 2015.[28] A total of 49 patients were registered with a case fatality rate of 85.7% (42/49).

Referral system

In the Pujehun district, two ambulances managed by the District Health Management Team (DHMT) were functioning in the pre Ebola period, but only 63% of the PHUs were able to use the service.[12 23] Emergency calls were not coordinated by the hospital and the transport costs were covered by the patients, dissuading many from using the service. During the outbreak, people came to associate the

ambulances with transporting Ebola infected patients, which further discouraged their use. A 24-h free-of-charge ambulance RS, transferring pregnant women with obstetric complications from the health centers to Pujehun hospital was implemented in January 2015. In the hospital a call center was established and the call center number was distributed to all the 77 PHUs. Private calls were considered only in the case of an emergency or if the staff of the PHU were not available. After confirming an emergency condition together with the PHU staff, the hospital midwife had the responsibility to authorize the referral. A nurse on duty from the maternity hospital accompanied the driver in each referral. Health personnel at hospital and PHUs levels were trained on Life Saving Skills – Emergency Obstetric and Newborn Care, including referral criteria and definition of MDOCs.[29]

Referrals were carried out by 3 ambulances, two positioned in the Pujehun MCH complex, and a third one in Jendema, bordering Liberia, on the opposite side of the Moa River. Around the Jendema area, 15 PHUs were located serving a population of approximately 80,000 inhabitants. Referrals in this area were made using the ambulances and by transferring patients at the river crossing point via a barge or a motor boat, depending on the flow rate of the river. Pediatric referrals were performed using private motor bikes available in the villages and hired from PHUs staff without the involvement of the call center. A referral form describing the clinical case and the justification for the referral was distributed to all the PHUs. The bike rider, after bringing the patient to the pediatric ward, delivered the referral form and received the reimbursement. For all patients carried to the hospital information was collected, including demographics, location, and the reason for contacting the RS. Community awareness activities were organized about the RS through meetings and radio discussions held by the DMHT, hospital health personnel, and local authorities.

Study design, population, and period

A prospective observational study using routinely collected health services data, from January 2012 to December 2017, was carried out. Three time periods were considered: pre- Ebola period (1st January 2012 – 30th May 2014); Ebola period (1st June 2014 – 28th February 2015); post- Ebola period (1st March 2015 – 31th December 2017). We considered the Ebola period from one month before the first confirmed case in the district (i.e. June 2014), to one month after the country being declared Ebola free (i.e. February 2015). This was done because in Sierra Leone the outbreak had started in other districts of the country before the first case registered in Pujehun and continued to affect other districts until November 2015. It is realistic to assume that public fear of potential EVD cases and lack of confidence in the health services persisted in the Pujehun population during that time.[14] In

addition, expanding the Ebola period enabled a full assessment of the impact of the disease with an adequate comparison with the two long periods before and after the Ebola epidemic.

Data collection

Data on MCH indicators was prospectively collected from hospital registers (maternity ward, delivery unit, pediatric ward, operating theatre). The following variables were collected on a monthly basis: 1) paediatrics admissions; 2) pediatric deaths; 3) maternity admissions; 4) maternal deaths; 5) deliveries; 6) C-sections; 7) MDOC cases. MDOC cases were collected using a dedicated database within the hospital and confirmed by a gynaecologist. All hospital maternal deaths were reviewed by DHMT and classified according to Maternal Death Surveillance and Response policy by MoHS. Paediatric deaths did not include stillbirths and early neonatal deaths, but only deaths of children admitted to the paediatric ward.

At community level, the following variables were collected from the local district Health Management Information System (HMIS): 1) family planning consultations per month; 2) deliveries per month; 3) ANC 1 per month; 4) ANC 4 per month. Different variables were collected from the two types of sites, based on the different services provided at community level (BEmOC) and at hospital level (CEmONC). Quarterly review meetings were organized with the staff in charge of the health facilities to address data discrepancies in the reports. Technical assistance was provided to the DHMT to improve timeliness, completeness, and accuracy of data regarding CEmOC and BEmONC services.

For the RS, data was collected from records of all of the study sites, including delivery registers, delivery logbooks, prenatal registers, referral registers, and death registers. Additional data was collected from the ambulance database and logbook. Records in the database were then validated by cross-checking the records with registers at the study sites.

Statistical analysis

For each indicator, a segmented seasonal autoregressive model of order 1 was estimated. The segments defined the three periods: before the EVD epidemic (January 2012 to May 2014), during the epidemic (June 2014 to February 2015), and after the epidemic (March 2015 to December 2017). Differences were considered statistically significant at $p < 0.05$. The analysis was performed using R.[30] The full description of the methodology of the statistical analysis is available in Annex 1.

Patient involvement

No patients were involved in defining the research question or the outcome measures, nor were they involved in the design and implementation of the study. There are no plans to involve patients in the dissemination of the results. The full statistical analysis is available in Annex 2.

RESULTS

Hospital level: Pre-Ebola period

At hospital level, for all indicators, the trend is stable during the pre Ebola period, without significant changes (Figure 2 and 3).

Hospital level: Ebola vs pre-Ebola period

At hospital level, the differences between Ebola period vs pre-Ebola averages show a statistically significant increase for institutional deliveries (11, 95% CI 2 to 21, p = 0.02) and for the reduction of maternal deaths (-1, 95% CI - 2 to 0, p = 0.042) (Table 1). There is also a statistically significant difference between the trend of Ebola period vs pre-Ebola period, for maternal admissions (7, 95% CI 4 to 11, p <0.001), MDOCs (4, 95% CI 1 to 7, p = 0.006), and institutional deliveries (4, 95% CI 2 to 6, p = 0.001) (Figure 2 and 3).

Hospital level: Ebola vs post-Ebola period

At hospital level, the differences between averages of the post Ebola vs Ebola are statistically significant for all indicators: institutional deliveries, C-sections, paediatric and maternity admissions, paediatric and maternity deaths, and MDOCs (Table 1). There is also a negative trend in the transition from Ebola to post Ebola for maternal admissions (-7, 95% CI -10 to -4, p <0.001), MDOCs (-4, 95% CI -7 to -1, p 0.009) and institutional deliveries (-3, 95% CI -5 to -1, p 0.001) (Figure 2 and 3).

Hospital level: Pre-Ebola vs post-Ebola period

The differences between averages of the pre-Ebola vs post-Ebola periods are also statistically significant for all indicators, except for maternal deaths (Table 1). The differences between trends between pre-Ebola vs post-Ebola period are only significant for pediatric admissions (3, 95% CI 0 to 5, p 0.035) (Figure 2 and 3).

Table 1 MCH indicators at hospital and community level

Indicator	Difference between average of Ebola period vs pre-Ebola period			Difference between average of Ebola period vs post-Ebola period			Difference between average of pre-Ebola period vs post-Ebola period		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
HOSPITAL LEVEL									
Maternal admissions	7	-7 to 22	0.333	43	28 to 58	<0.001	50	37 to 64	<0.001
Maternal deaths	-1	-2 to 0	0.042	2	1 to 3	0.001	1	0 to 2	0.135
Institutional deliveries	11	2 to 21	0.02	28	18 to 38	<0.001	39	31 to 48	<0.001
C-sections	5	-1 to 11	0.13	15	8 to 21	<0.001	19	13 to 25	<0.001
MDOC	2	-11 to 14	0.782	41	30 to 54	<0.001	43	31 to 54	<0.001
Pediatric admissions	1	-39 to 40	0.968	133	92 to 174	<0.001	134	98 - 170	<0.001
Pediatric deaths	-1	-6 to 5	0.826	9	3 to 15	0.004	8	3 to 14	0.003
COMMUNITY LEVEL									
Institutional deliveries	148	99 to 196	<0.001	-10	-59 to 39	0.695	138	93 to 183	<0.001
ANC 1	74	3 to 145	0.042	-48	-122 to 26	0.2	26	-40 to 91	0.448
ANC 4	80	21 to 139	0.008	23	-38 to 84	0.461	103	48 to157	<0.001
Family planning	490	-92 to 1073	0.099	-262	-855 to 330	0.386	228	-293 to 750	0.391

Community level: Pre-Ebola period

At community level, all indicators in the months before Ebola showed a positive trend. There was a monthly average increase of 8 institutional deliveries (95% CI 6 to 10, p<0.001); a monthly average increase of 7 ANC 1 (95% CI 4 to 10, p<0.001) and 6 ANC 4 (95% CI 4 to 8, p<0.001), and a monthly average increase of 69 women accessing family planning services (95% CI 42 to 95, p<0.001) (Figure 4).

Community level: Ebola vs pre-Ebola period

At community level, with the exception of family planning, the differences between averages of Ebola period vs pre-Ebola are statistically significant for all indicators: institutional deliveries (148, 95% CI 99 to 196, p <0.001), ANC 1 (74, 95 % CI 3 to 145, p = 0.042), and ANC 4 (80, 95% CI 21 to 139, p = 0.008) (Table 1). The difference between trends (Figure 3) of the Ebola vs pre-Ebola period are not significant for any of the indicators considered (Figure 4).

Community level: Ebola vs post-Ebola period

At community level, the differences between averages (Table 1) and the difference between trends (Figure 4) of the Ebola vs post-Ebola period are not significant for any of the indicators considered.

Community level: Pre-Ebola vs post-Ebola period

The differences between averages of the pre-Ebola vs post-Ebola are statistically significant, with an increase in institutional deliveries (138, 95% CI 93 to 183, p <0.001) and ANC 4 (103, 95% CI 48 to 157,

p < 0.001) (Table 1). However, there is a negative difference between trends among the two periods, for all the variables considered: institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and most significantly for family planning (-85, 95% CI -119 to -51, p <0.001) (Figure 4).

Referral system: **Obstetric and paediatric results**

Between January 2015 and December 2017 there were 2,450 obstetric referrals. Of these, 1,574 (64%) were MDOC, which represent 70% of all the 2,233 MDOCs treated in the hospital over the same period. The baseline characteristics and reasons for MDOCs collected through the RS are reported on Table 2. At the same time, 4,671 paediatric patients were admitted in the hospital through the RS, representing 72% of the 6,518 total admission during the same period. Reasons for paediatric referrals are shown on Table 3.

Table 2 Baseline characteristics and reasons for MDOCs collected through RS, period 2015 - 2017

Age (years)	N	%
Mean	25,3	SD 7
12-19	442	28%
20-29	613	39%
30-39	464	29%
40+	43	3%
Unknown	12	1%
Number of previous deliveries		
0	474	30%
1 or 2	377	24%
3 or 4	292	19%
5 or 6	207	13%
7+	212	13%
Unknown	12	1%
MDOC treated		
Prolonged/obstructive labour	848	54%
Antepartum haemorrhage	195	12%
Severe pre-eclampsia/eclampsia	165	11%
Abortium complicatium	117	7%
Post-partum haemorrhage	157	10%
Ectopic pregnancy	24	2%
Rupture uterus	30	2%
Sepsis	38	2%
Total	1574	100%

Table 3 Reasons for paediatric RS, period 2015-2017*

Reason for referral	Number	%
Malaria	1540	30%
Anemia	910	18%
Pneumonia/ARI**	830	16%
Diarrhoea and vomiting	495	10%
Malnutrition	274	5%
Convulsion	186	4%
Hernia/Hydrocele	165	3%
Sepsis/Septicemia	127	2%
Dehydratation	48	1%
Burn	30	1%
Others	522	10%
Total	5127	100%

* For a number of patients, more than one suspected diagnosis for referral was reported; ** Acute Respiratory Infection.

DISCUSSION

This study presents for the first time trends in utilization of MCH services before, during, and after Ebola, at hospital and community level from the country most heavily affected by the Ebola epidemic. It also presents data on the restructured and reorganised RS, which started immediately after the EVD outbreak. The study shows that there was a decrease in all MCH indicators and service uptake immediately after the onset of the outbreak, with a levelling or increase during the EVD period. In the post-Ebola period, all indicators (except for maternal deaths) showed an increase, in comparison with the pre-Ebola period. This was particularly marked at hospital level because the post Ebola reinforcement of the RS led to an increase in pediatric admissions, maternal admissions, and consequently a rise of institutional deliveries, C-sections, and MDOCs. In addition, while at the hospital level trends in the post-Ebola period are in line with the pre-Ebola, at community level there is a negative trend compared to the pre-Ebola period for all indicators taken into consideration. The study presents results in contrast to other studies that showed a decline in MCH services in the Ebola and post-Ebola periods.[6 31 32]

Pre Ebola and Ebola periods

As mentioned above, the approach implemented in the Pujehun district [17 28] avoided vertical interventions only focused on the containment of the EVD epidemic. It worked on strengthening all the components of the health system - before, during, and long after the epidemic. This approach may have contributed to reducing the spread of infection and the impact of the disease on MCH services.[17 18] As shown by this paper, at community level family planning, ANC, and institutional deliveries, were affected only at the beginning of the Ebola outbreak with a small decrease in service utilization. In contrast, Jones et al., evaluated the number of antenatal and postnatal visits, institutional births, emergency obstetric care (EmOC), maternal deaths and stillbirths across 13 districts of Sierra Leone for 10 months during, and 12 months prior to the epidemic. They found that following the onset of the epidemic there was an 18% decrease in the number of women attending ANC visits and an 11% decrease in the number of women attending for birth at healthcare facilities.[14]

During the Ebola epidemic, the Pujehun hospital maintained C-sections and delivery volume at pre-Ebola levels. There was a stable number of patients attending the hospital during the Ebola outbreak, as shown by the number of maternal and pediatric admissions. The study of Brolin and colleagues focused on in-hospital deliveries and C-section volume in Sierra Leone. They showed that nationwide, albeit with substantial variation between districts, in-hospital deliveries and C-sections

decreased by over 20% during the Ebola outbreak, mainly because of the closure of not-for-profit hospitals.[6] Brolin also noted that in general, at hospital level, in Sierra Leone those facilities that remained open performed about the same number of deliveries and C-sections after the onset of the EVD outbreak as they did before.[6] This seems to indicate that the decrease observed at national level was related to the closing of key health facilities. The number of Ebola cases was not uniform throughout districts in Sierra Leone and Pujehun was one of the least affected districts. The low number of cases may also have helped to maintain public confidence in service provision and uptake of services.[7 8]

Post Ebola period

There is a shortage of data in Sierra Leone and the other West Africa countries affected regarding the resumption of services after the epidemic. Pujehun district showed contrasting results at community level. Results of the post Ebola vs pre-Ebola show an increase of activities for institutional delivery and ANC 4. However, there is a negative trend among the two periods, for the variables taken into consideration, namely institutional deliveries (-7, 95% CI -10 to -4, p <0.001) ANC 1 (-6, 95% CI -10 to -3, p <0.001), ANC 4 (-8, 95% CI -11 to -5, p <0.001) and family planning (-85, 95% CI -119 to -51, p <0.001). In 2017, the Pujehun district showed a coverage of 98% for ANC 1 (98% in 2013), 91% for ANC 4 (76% at national level in 2013) and 90% for institutional deliveries (62% in 2013).[33 34] The initial intervention carried out by DwA in the period 2012-2014 at the community level probably increased these percentages, with an initial growth of the trend that had been slowing down in the years 2016-2017. Possible explanations for this may include: bypassing, i.e. using alternative health care instead of free or subsidized public clinics; increased opportunities to get transport to seek healthcare in neighbouring districts; reduced demand for MCH services at community level; and reduced quality of MCH services at PHUs.

A study by Camara et al. in a rural district of Guinea showed a considerable recovery gap in the post-Ebola period for ANC (37%) and institutional deliveries (34%).[31] Also Delamou et al. noted a significant reduction in the average number of ANC visits and institutional deliveries during the Ebola outbreak, in 6 districts of Guinea, and the overall post-outbreak trends did not suggest recovery.[32] By contrast, Wagenaar et al., which analysed 10 primary care indicators in Liberia, before, during, and after the Ebola outbreak, showed significant positive trends during the post-EVD period for ANC and institutional deliveries.[35]

There are multifactorial and complex reasons for the decline of family planning in the Pujehun district. The activities that MoHS and DwA implemented from 2012 onwards were maintained during and after the EVD epidemic. However, a general decrease in the availability of healthcare personnel and international aid was observed and this could be a factor in the family planning decline. A possible stock-out of family planning methods has also been suggested as a reason for the decrease.[25] In addition, a reduction in demand for family planning in the post Ebola period could account for the decline of the service. Experiencing a disaster can trigger the desire to "rebuild" communities, reducing the need for family planning methods,[36] or communities may prefer traditional methods of contraception.[37] However, the reduction in family planning use in Pujehun district did not translate into an increase in institutional deliveries as occurred in neighbouring Liberia.[38] Although no further transmissions of Ebola took place in the Pujehun district after November 2015, the awareness of the ongoing transmission elsewhere in Sierra Leone, in Guinea and Liberia might have influenced health seeking behaviours.[39 40] However, this does not seem to have influenced other types of MCH services at community level. For comparison, the above mentioned study of Camara et al. showed that the utilization of family planning declined by 51% during the Ebola outbreak but recovered in the post-Ebola period.[31]

At hospital level, the situation is different. In the post-Ebola period, there was a significant increase in the volumes of activities: pediatric and maternal admissions, MDOC cases, deliveries, and C-sections. This increase can be directly linked to the reorganization and strengthening of the RS immediately after the Ebola epidemic. Based on the 3 delays theory,[41] in Pujehun it was decided to tackle the second delay, a lack of accessibility to health services. The distance to the hospital as well as lack of accessible and affordable vehicles were recognized as significant barriers when attempting to access CEmONC services at the hospital.[42 43] The success of the RS service can be linked to the integration of the key components needed for a successful service, namely: i) a transport system which took account of the specific geographical characteristics of the district;[42] ii) an effective communication system with a call center in contact with all PHUs of the district, the ambulance drivers, and the hospital; iii) training of all the PHU staff on the recognition of obstetric emergencies and on the RS.[44 45] Several meetings were planned with local community leaders and religious leaders to raise awareness of the importance of giving birth in health facilities. Prohibitive costs have been shown to be a major factor in preventing women accessing health facilities during childbirth in Sierra Leone.[42 46 47] Meetings were also organised to inform the population that the service was free of charge, and to give reassurance that the ambulances carried no risk of Ebola infection to people using

them. The increase in complicated cases treated at the hospital did not translate into an increase in maternal and pediatric deaths, reflecting positively on the quality of care provided. The maternity ward death rate remained around 1% throughout the 2012-2017 study period. The differences in average death rates during the period 2015-2017 among referred and not referred pediatric patients were 10.5% and 4.3% respectively. This showed that the pediatric RS works for the most critical cases able to reach the hospital in time.

CONCLUSIONS

There are a number of contextual factors and limitations that should be taken into account in the analysis of the results of this study. The data refers to a single area of Sierra Leone and therefore our sample cannot be considered representative of the country as a whole. We defined our distinct period of EVD outbreak arbitrarily, from one month before the first case in the district to three months after the last case in the district. This was done because the EVD crisis affected areas of the country outside Pujehun prior to and after outbreak within Pujehun. The official end of the EVD epidemic for Sierra Leone was declared on March 17, 2016, and for the countries of Guinea and Liberia was declared on June 1, 2016. All the results should be taken with some degree of statistical caution, because no correction was performed to take into account the multiplicity of the tests carried out. Finally, our study assumed that no other interventions in addition to those described occurred concurrently with the Ebola epidemic.[18] Similarly, we assumed that no other substantial interventions in addition to the re-organisation of the RS happened in the post-Ebola period which would have affected the service trends that we observed. The Pujehun district had 49 confirmed EVD cases. This number is much lower than in other districts. If it is true that the fear of Ebola may have prevented people from accessing health services, the small number of EVD cases in the community may have also raised confidence, leading to the increase of utilization rates after the initial drop. The strength of this study is that it uses data from a remote rural district in Sierra Leone, with a 6-year observational period. The pre, intra, and post-Ebola periods data, allowed a comparison between trends. DwA was working in this community before the outbreak began, which gave an advantage of knowledge of the setting when the epidemic began, which in turn facilitated mitigating measures to be put in place. In addition, this allowed a collection of data in a prospective way, reducing the potential bias in the accuracy of the data reported by other studies.[6 14 32 35]

Failures in providing effective health care are associated with a chiefly vertical focus on outbreak control.[19-21] The approach implemented in the Pujehun district worked on strengthening all the

components of the health system - governance, human resources, community involvement - before, during and, after the epidemic.

The strengthening of the health system in the district, compared to other districts, allowed the containment of the epidemic and, above all, to maintain and strengthen MCH services as shown by the data reported in the paper. Health facilities in the district, both at community and hospital level, were able to maintain their services during the epidemic, overcoming public fear of Ebola and lack of confidence in service providers, which led to the public staying away from facilities in other districts in Sierra Leone.[14] In post-crisis situations, "windows of opportunity" are opened for redirecting the policies of the national health systems, renovating specific sectors (e.g. human resources, epidemiological surveillance systems, financing, etc.) and renewing services/practices at the operational level.[48] In Pujehun the implementation of an RS immediately after the acute Ebola phase might have reduced delays in patients accessing care and enabled a significant improvement in all MCH indicators at hospital level. Other studies have also found that using this window of opportunity to introduce systems such as performance based financing can also produce positive outcomes.[49] As Sierra Leone continues its recovery, there is a need to quantify the impact of the outbreak on MCH care to guide long-term strategies for MHC services. This study provides evidence on strategies to increase the resilience of fragile healthcare services and the importance of NGOs and government collaboration to bring about change.

Figure 1 Study area, the Pujehun district in Sierra Leone.

Figure 2 Maternal and pediatric admissions at hospital level.

Figure 3 C-sections, deliveries, MDOCs, pediatric and maternal deaths at hospital level.

Figure 4 ANC 1, ANC 4, deliveries, and family planning at community level.

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Patient consent for publication Obtained.

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Disclaimer The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the affiliated organisations.

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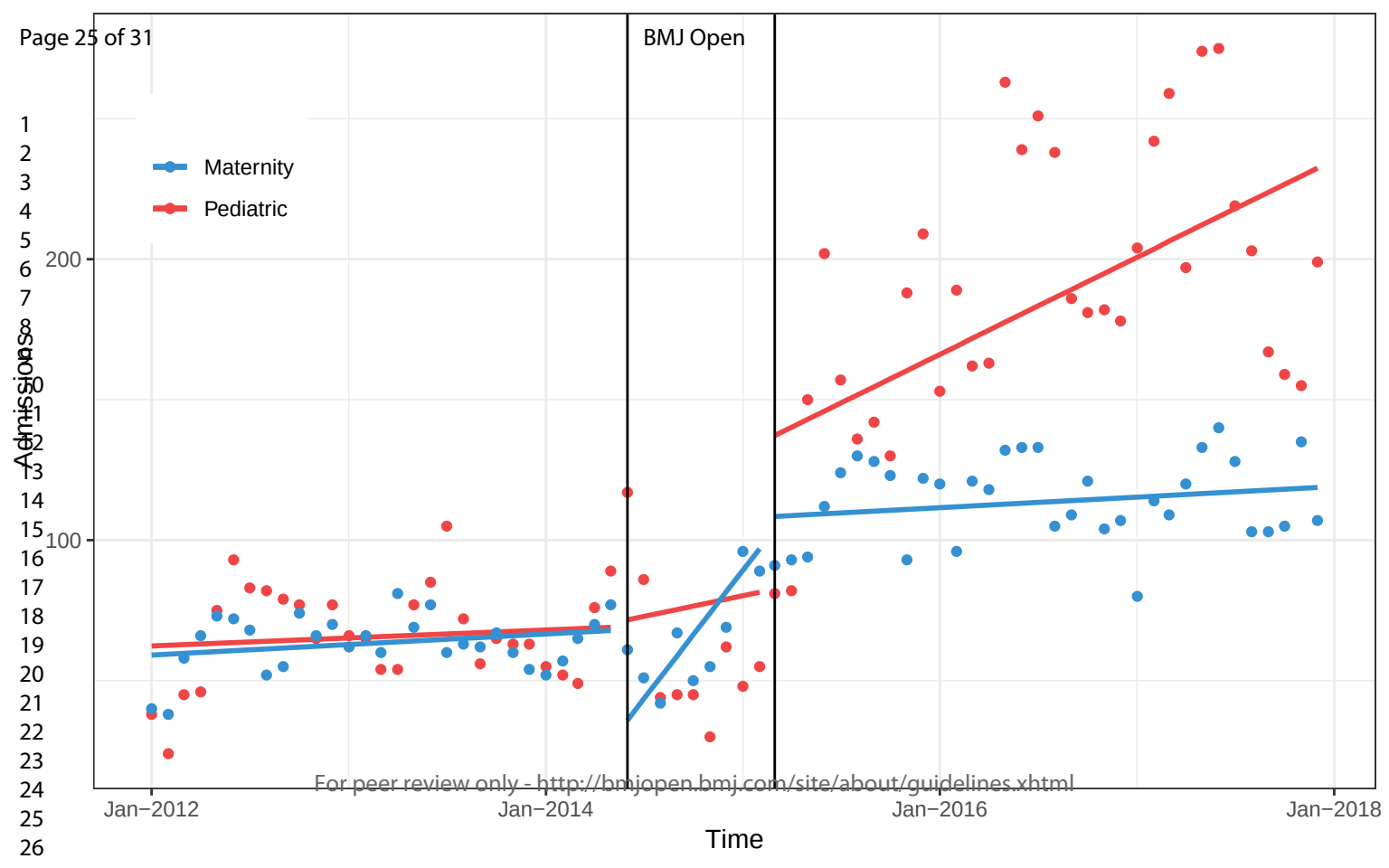

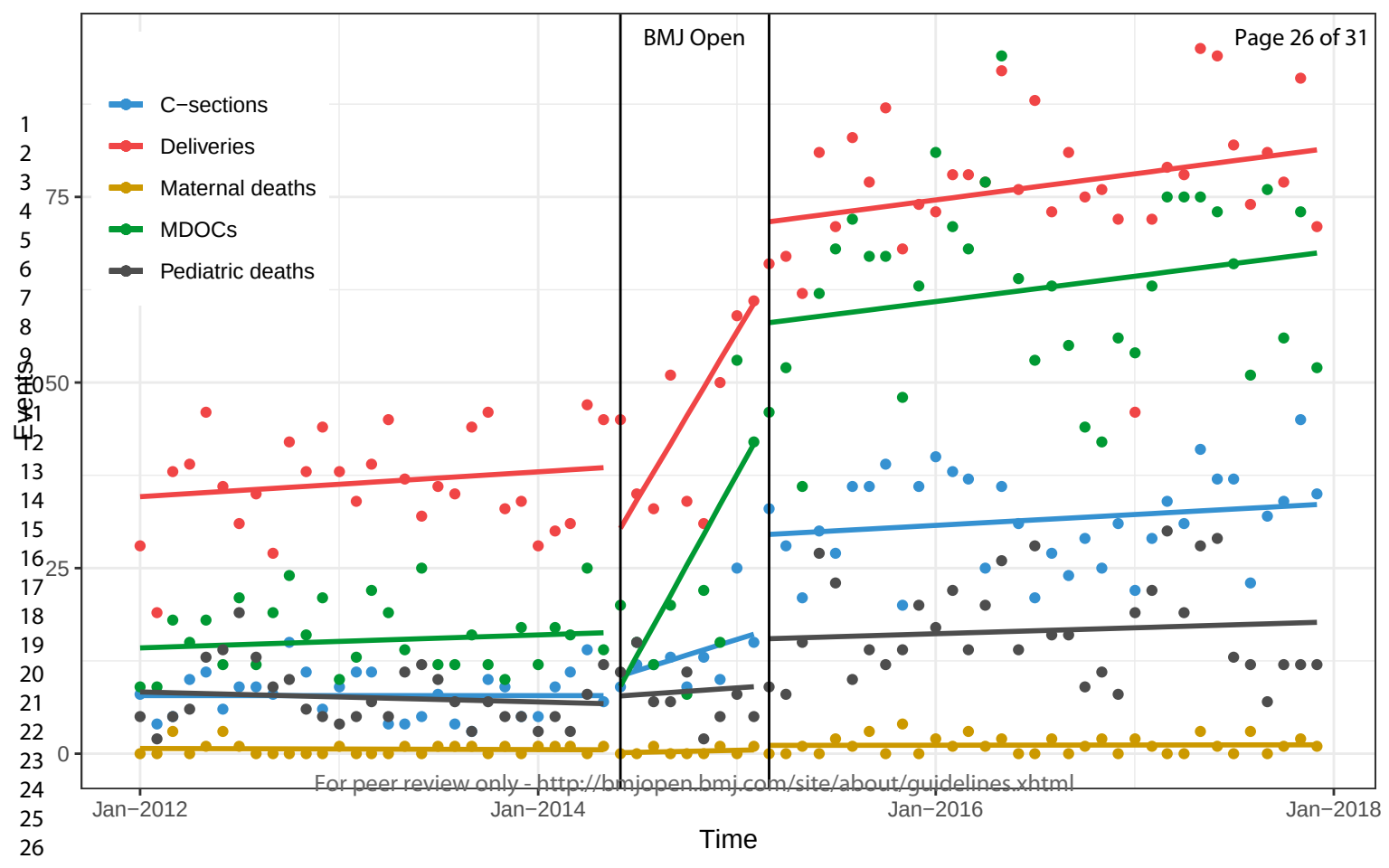

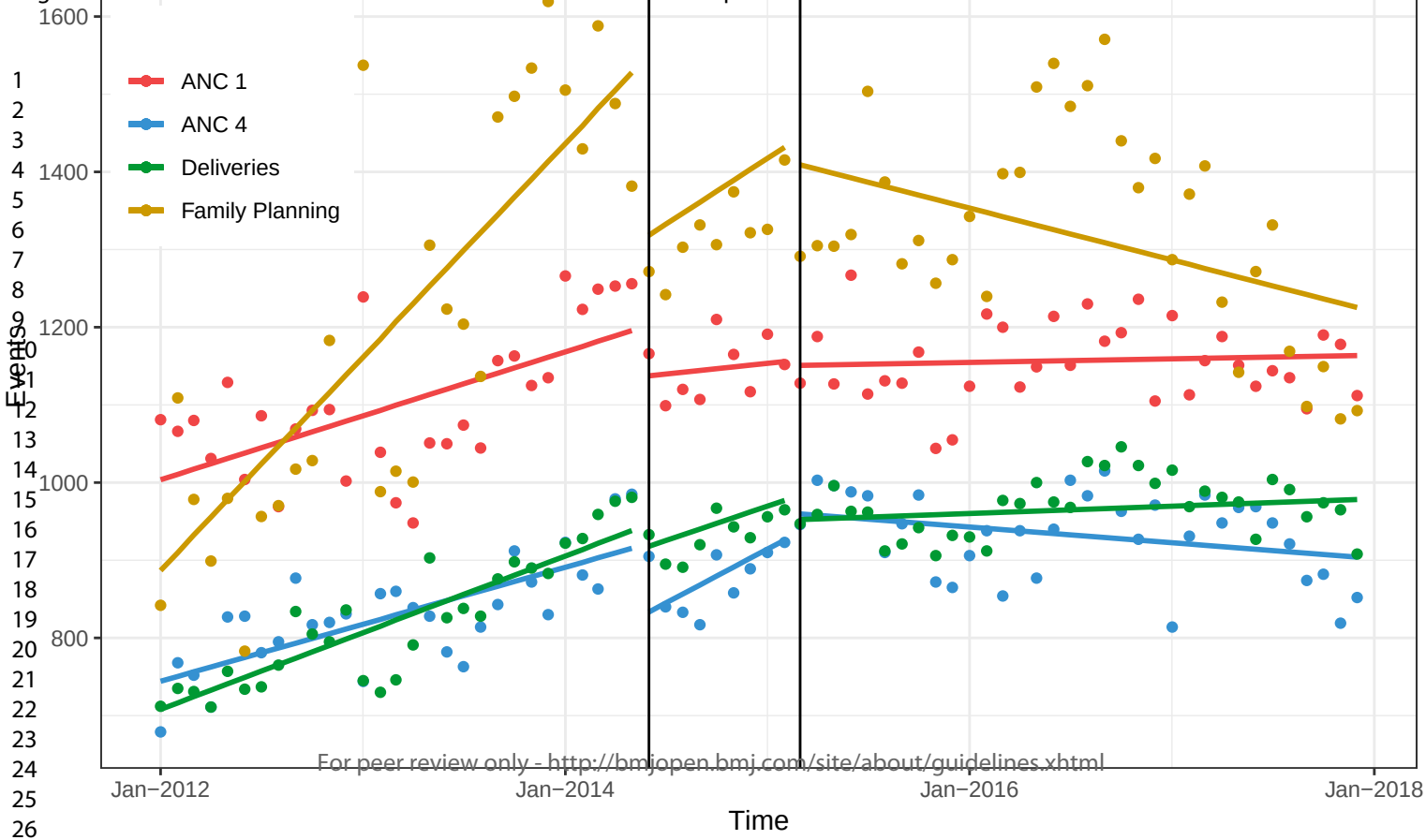

ANNEX 1

Statistical analysis

For each indicator, a segmented seasonal autoregressive model of order 1 was estimated. The segments defined the three periods: before the EVD epidemic (January 2012 to May 2014), during the epidemic (June 2014 to February 2015), and after the epidemic (March 2015 to December 2017). The model for each indicator Y_t collected at hospital or community level was as follows: $Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \beta_4 Z_t + \beta_5 Z_t T_t + \beta_6 Month + \varepsilon_t$. β_0 estimates the number of individuals using the service at the beginning of the pre-Ebola period; β_1 estimates the average monthly change in the number using the service over the pre-outbreak period; T_t is the time since the start of the study; β_2 represents the change in the level of service use that occurred in the period immediately after the EVD period (designated by indicator variable X_t); β_3 represents the difference between the trend in service use during the EVD outbreak compared to the pre-disease period; β_4 represents the change in service use that occurred in the period immediately after the end of the outbreak (post-outbreak period designated by indicator variable Z_t); β_5 is the difference between the trend in service use during the period after the Ebola virus disease outbreak compared with the period during the outbreak period; β_m represents a series of indicator variables for each calendar month, and t is the random error term. Overall trends across the periods and the comparisons among trends were calculated as follows: linear trend during the outbreak = $\beta_1 + \beta_3$; linear trend after the outbreak = $\beta_1 + \beta_3 + \beta_5$; and linear trend after the outbreak vs linear trend before the outbreak = $\beta_3 + \beta_5$. Average levels across the periods and their comparisons were calculated as follows: average during the outbreak = $\beta_0 + \beta_2$; average after the outbreak = $\beta_0 + \beta_2 + \beta_4$; and difference between after the outbreak and before the outbreak = $\beta_2 + \beta_4$. Differences were considered statistically significant at $p < 0.05$. The analysis was performed using R.[30]

ANNEX 2.
Full results analysis.

Maternal admissions, maternal deaths, C-sections, and MDOCs at hospital level.

	Maternal admissions			Maternal deaths			C-sections			MDOC		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	7	-7 to 22	0.333	-1	-2 to 0	0.042	5	-1 to 11	0.13	2	-11 to 14	0.782
Difference between average of post-Ebola period vs Ebola period	43	28 to 58	<0.001	2	1 to 3	0.001	15	8 to 21	<0.001	41	30 to 54	<0.001
Difference between average of post-Ebola period vs pre-Ebola period	50	37 to 64	<0.001	1	0 to 2	0.135	19	13 to 25	<0.001	43	31 to 54	<0.001
Pre-Ebola period												
Number of events over pre-Ebola period (β_0)	49	37 to 61	<0.001	1	0 to 2	0.026	9	4 to 14	0.001	16	5 to 26	0.003
Trend in number over pre-Ebola period (β_1)	0	0 to 1	0.281	0	0 to 0	0.677	0	-0 to 0	0.999	0	0 to 0.5	0.768
Ebola period												
Average monthly change in number over Ebola period (β_2)	-40	-60 to -19	<0.001	0	-2 to 0	0.480	2	-7 to 11	0.668	-11	-29 to 6	0.207
Difference between trend of Ebola period vs pre-Ebola period (β_3)	7	4 to 11	<0.001	0	0 to 0	0.605	1	-1 to 2	0.346	4	1 to 7	0.006
Post-Ebola period												
Average monthly change in number during post-Ebola period (β_4)	11	-7 to 30	0.23	1	0 to 2	0.258	13	5 to 21	0.001	16	0 to 32	0.044
Difference between trend of post-Ebola period vs Ebola period (β_5)	-7	-10 to -4	<0.001	0	0 to 0	0.665	-1	-2 to 0.8	0.433	-4	-7 to -1	0.009
Difference between trend of post-Ebola vs pre-Ebola period ($\beta_3 + \beta_5$)	0	-1 to 1	1	0	0 to 0	0.657	0	0 to 0	0.431	0	0 to 1	0.503

Pediatric admissions, pediatric deaths, and institutional deliveries at hospital level.

	Pediatric admissions			Pediatric deaths			Institutional deliveries		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	1	-39 to 40	0.968	-1	-6 to 5	0.826	11	2 to 21	0.02
Difference between average of post-Ebola period vs Ebola period	133	92 to 174	<0.001	9	3 to 15	0.004	28	18 to 38	<0.001
Difference between average of post-Ebola period vs pre-Ebola period	134	98 - 170	<0.001	8	3 to 14	0.003	39	31 to 48	<0.001
Pre-Ebola period									
Number of events over pre-Ebola period (β_0)	46	10 to 82	0.011	7	2 to 12	0.007	27	19 to 34	<0.001
Trend in number over pre-Ebola period (β_1)	0	-2 to 2	0.808	0	0 to 0	0.641	0	0 to 0	0.42
Ebola period									
Average monthly change in number over Ebola period (β_2)	1	-48 to 50	0.955	1	-7 to 9	0.836	-12	-25 to 1	0.072
Difference between trend of Ebola period vs pre-Ebola period (β_3)	1	-8 to 10	0.823	0	-1 to 2	0.763	4	2 to 6	0.001
Post Ebola period									
Average monthly change in number over post-Ebola period (β_4)	53	5 to 100	0.029	6	-1 to 14	0.086	11	-1 to 22	0.064
Difference between trend of post-Ebola period vs Ebola period (β_5)	2	-7 to 10	0.702	0	-1 to 1	0.899	-3	-5 to -1	0.001
Difference between trend of post-Ebola vs pre-Ebola period ($\beta_3 + \beta_5$)	3	0 to 5	0.035	0	0 to 0	0.423	0	0 to 0	0.486

Institutional delivery, ANC 1, ANC 4 and family planning at community level.

	Institutional delivery			ANC 1			ANC 4			Family planning		
	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value	β	95% CI	p value
Difference between average of Ebola period vs pre-Ebola period	148	99 to 196	<0.001	74	3 to 145	0.042	80	21 to 139	0.008	490	-92 to 1073	0.099
Difference between average of post-Ebola period vs Ebola period	-10	-59 to 39	0.695	-48	-122 to 26	0.2	23	-38 to 84	0.461	-262	-855 to 330	0.386
Difference between average of post-Ebola period vs pre-Ebola period	138	93 to 183	<0.001	26	-40 to 91	0.448	103	48 to 157	<0.001	228	-293 to 750	0.391
Pre Ebola period												
Number of events over pre-Ebola period (β_0)	688	643 to 732	<0.001	1062	1002 to 1121	<0.001	694	644 to 743	<0.001	2690	2187 to 3193	<0.001
Trend in number over pre-Ebola period (β1)	8	6 to 10	<0.001	7	4 to 10	<0.001	6	4 to 8	<0.001	69	42 to 95	<0.001
Ebola period												
Average monthly change in number over Ebola period (β_2)	-28	-90 to 34	0.382	-61	-161 to 40	0.238	-94	-176 to -11	0.027	-671	-1431 to 89	0.084
Difference between trend of Ebola period vs pre-Ebola period (β_3)	-1	-12 to 10	0.881	-5	-21 to 12	0.591	5	-8 to 19	0.437	-26	-156 to 104	0.692
Post Ebola period												
Average monthly change in number during post-Ebola period (β_4)	-25	-81 to 30	0.37	-5	-94 to 83	0.906	35	-37 to 109	0.343	-51	-759 to 657	0.888
Difference between trend of post-Ebola period vs Ebola period (β_5)	-7	-17 to 4	0.228	-2	-18 to 15	0.819	-13	-27 to 0	0.056	-59	-186 to 68	0.361
Difference between trend of post-Ebola vs pre-Ebola period (β3 + β5)	-7	-10 to -4	<0.001	-6	-10 to -3	<0.001	-8	-11 to -5	<0.001	-85	-119 to -51	<0.001

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6	
Objectives	3	State specific objectives, including any prespecified hypotheses	6	
Methods				
Study design	4	Present key elements of study design early in the paper	7	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8	
Participants	6	(*a*) *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8	
Bias	9	Describe any efforts to address potential sources of bias	16-17	
Study size	10	Explain how the study size was arrived at		

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy NA	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9-12
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	9-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-11
		(*b*) Report category boundaries when continuous variables were categorized	9-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-11

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.